US Army Corps
of Engineers
Philadelphia District

New Jersey Shore Protection Study

Brigantine Inlet to Great Egg Harbor Inlet

Absecon Island Interim Feasibility Study

Volume 1

Final Feasibility Report
and
Final Environmental Impact Statement
And

Appendix C: Environmental Investigations and Coordination
Appendix D: Pertinent Correspondence
Appendix G: Public Review Comments and Responses

August 1996

US Army Corps of Engineers
Philadelphia District

NEW JERSEY SHORE PROTECTION STUDY

BRIGANTINE INLET TO GREAT EGG HARBOR INLET

ABSECON ISLAND INTERIM FEASIBILITY STUDY

VOLUME 1

FINAL FEASIBILITY REPORT
AND
FINAL ENVIRONMENTAL IMPACT STATEMENT
AND
APPENDIX C: ENVIRONMENTAL INVESTIGATIONS AND COORDINATION
APPENDIX D: PERTINENT CORRESPONDENCE
APPENDIX G: PUBLIC REVIEW COMMENTS AND RESPONSES

August 1996

DISTRICT ENGINEER'S STATEMENT OF TECHNICAL REVIEW

COMPLETION OF TECHNICAL REVIEW

The District has completed the Feasibility Study of Absecon Island. Certification is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. The technical review was accomplished by the following:

TECHNICAL ELEMENT	STUDY TEAM MEMBERS	REVIEW TEAM MEMBERS
PLANNING DIVISION		
PLANNING DIVISION		Robert L. Callegari
PLANNING DIVISION		John Burnes, P.E.
PROJECT DEVELOPMENT BRANCH		Lee Ware, P.E.
COASTAL PLANNING SECTION	Doug Gaffney	Ted Keon
ENVIRONMENTAL RESOURCES BRANCH	Beth Brandreth/Mike Swanda	Jerry Pasquale
ECONOMICS BRANCH	Sharon Greyson	Robert Selsor
ENGINEERING DIVISION		
ENGINEERING DIVISION		Dennis Kamper, P.E.
DESIGN BRANCH		Leonard Lipski, P.E.
CIVIL PROJECTS MANAGEMENT BRANCH	Megan Coll	Gary Rohn, P.E.
GEOTECHNICAL SECTION	Brian Murtaugh	Scott Fritzinger, P.E.
CIVIL/STRUCTURAL DESIGN SECTION	Gizzella Geissella	Gus Rambo, P.E.
HYDROLOGY & HYDRAULICS BRANCH	Monica Chasten	George Sauls, P.E.
COST ENGINEERING BRANCH	Sterling Johnson	Jose Alvarez, P.E.
OTHER DIVISIONS		
REAL ESTATE DIVISION	Mike Hewitt	Sue Lewis

FINDINGS AND RESPONSE

During the technical review, compliance with clearly established policy principles and procedures, utilizing clearly justified and valid assumptions, were verified. This included assumptions; methods, procedures, and material used in analysis; alternatives evaluated; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. Significant concerns and the explanation of the resolution are as follows:

There are no significants concerns for this project.

CERTIFICATION OF TECHNICAL REVIEW:

As noted above, all concerns resulting from technical review of the project have been resolved. The report and all associated documents required by the National Environmental Policy Act, has been fully reviewed and s approved as sufficient. The project may proceed to the Plans and Specification Phase.

Chief, Planning Division	8/22/96 Date
Chief, Engineering Division	8/22/96 Date
Chief, Operations Division	22 Aug 96 Date
Chief, Real Estate Division	8/22/96 Date

BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

Absecon Island Interim Study

Final Feasibility Report
August 1996

SYLLABUS

This report presents the results of a feasibility phase study to determine an implementable solution and the extent of Federal participation in a storm damage reduction project for the communities of Atlantic City, Ventnor, Margate and Longport, New Jersey. This feasibility study is prepared based on the recommendations of the reconnaissance study completed in 1992, which identified possible solutions to the storm damage problems facing the study area. The reconnaissance study also determined that such a solution was in the Federal interest and identified the non-Federal sponsor.

The feasibility study was cost shared between the Federal Government and State of New Jersey through the New Jersey Department of Environmental Protection (NJDEP), and was conducted under the provisions of the Feasibility Cost Sharing Agreement executed 20 January 1993. The feasibility study was initiated in March 1993.

The Absecon Island study area stretches for approximately 9.2 miles along Atlantic City's Absecon Inlet frontage and the ocean coast of Absecon Island. The area has been subject to major flooding, erosion and wave attack during storms, causing damage to structures, and, since 1992, was twice declared a National Disaster Area by the President of the United States. In recent years, continued erosion has resulted in a reduction of the height and width of the beachfront, which has increased the potential for storm damage.

The feasibility study evaluated various alternative plans of improvement formulated on hurricane and storm damage reduction. The NED plan has been identified as a 200 foot wide berm at elevation + 8.5 ft NGVD with a dune at elevation + 16 ft NGVD with a crest width of 25 feet for the oceanfront of Atlantic City, a 100-foot wide berm at elevation + 8.5 ft NGVD with a dune at elevation + 14 ft NGVD with a crest width of 25 feet for the oceanfront of Ventnor, Margate & Longport, and two timber bulkhead sections with top elevation of +14 NGVD and revetment along the inlet frontage of Atlantic City. The selected oceanfront plans include dune grass, dune fencing and suitable advance beachfill and periodic nourishment to ensure the integrity of the design. The plan requires 6,174,013 cubic yards of initial fill to be placed from designated offshore borrow sites, and subsequent periodic nourishment of 1,666,000 cubic yards every 3 years for 50 years.

The feasibility report is based on October 1995 price levels and the Federal interest rate of 7.625%. The economic analysis for the selected plan indicates that the proposed plan will provide annual benefits of $16,356,000 which when compared to annual cost of the proposed plan of $8,486,000, yields a benefit to cost ratio of 1.9 with $7,870,000 in net excess benefits.

The total initial project cost of construction is currently estimated to be $52,146,000 (at October 1995 price levels). The Federal share of this first cost is $33,896,000, and the non-Federal share $18,251,000. Periodic nourishment is estimated at $12,188,000 on a three year cycle and will be similarly cost shared 65-35 for the life of the project. The ultimate project cost which includes initial construction, fifty years of periodic nourishment and monitoring is currently estimated to be $265,456,000 (at October 1995 price levels).

The proposed plan is technically sound, economically justified, and socially and environmentally acceptable; however, the current Administration's budgetary policy precludes further Federal participation in the design and construction of hurricane and storm damage reduction projects. This means that the feasibility phase of study will be completed, however, Federal funds will not be budgeted future construction of this project.

DESCRIPTION OF THE SELECTED PLAN
FOR ABSECON ISLAND

Project Title: New Jersey Shore Protection Study, Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Absecon Island Interim Report

Description: The proposed project provides a protective beach with a dune system to reduce the potential for storm damage in the communities of Atlantic City, Ventnor, Margate & Longport, NJ, and bulkheading along Atlantic City's Absecon Inlet frontage.

Beach Fill	
Volume of Initial Fill	6,174,013 yd^3
Volume of Renourishment Fill	1,666,000 yd^3
Interval of Renourishment	3 yrs
Length of Fill	42,825 l.f.
Width of Beach Berm (Atlantic City)	200 ft.
Width of Beach Berm (Ventnor, Margate & Longport)	100 ft.
With of Dune Crest	25 ft.
Timber Bulkheads with Stone Revetment	
Oriental Avenue to Atlantic Avenue	1,050 l.f.
Madison Avenue to Melrose Avenue	550 l.f.
Elevations	
Dune Crest (Atlantic City)	+16 ft. NGVD
Dune Crest (Ventnor, Margate & Longport)	+14 ft. NGVD
Beach Berm	+8.5 ft. NGVD
Bulkhead Top Elevation	+14 ft. NGVD
Slopes	
Dune (Landward)	1V:5H
Dune (Seaward)	1V:5H
Beach Berm to Existing Bottom	1V:30H
Stone Revetment	1V:2H
Dune Appurtenances	
Grass Planting	91 Acres
Sand Fencing	63,675 l.f.
Vehicle Access	
Dune Walkovers	

Project Costs	
Ultimate Project Cost (Oct. 1995 P.L.)	$265,456,000
Initial Cost	$ 52,146,000
Annualized (Discounted 7.625%)	$ 8,486,000
Average Annual Benefits	
Storm Damage Reduction	$ 8,912,000
Reduced Maintenance	$ 2,000
Benefits During Construction	$ 479,000
Recreation	$ 6,963,000
Benefit/Cost Ratio	1.9
Cost Apportionment (First Cost)	
Federal	$33,896,000
Non-Federal	$18,251,000

NOTE: All elevations referenced to the National Geodetic Vertical Datum (NGVD), 1929.

BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

Absecon Island Interim Study

Revised Draft Feasibility Report
April 1996

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INTRODUCTION

1. The New Jersey Shore Protection Study is an ongoing study of the shore protection and water quality problems facing the entire ocean coast and back bays of New Jersey. The study will provide recommendations for future actions and programs to reduce storm damage, minimize the harmful effects of shoreline erosion, and improve the information available to coastal planners and engineers to preclude further water quality degradation of the coastal waters. This report presents the formulation of the National Economic Development (NED) plan for the first interim study of the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study. This interim study focuses on Absecon Island.

2. This document was prepared in accordance with ER 1105-2-100 (Civil Works Planning Guidance Notebook), ER 1110-2-1150 (Engineering & Design for Civil Works Projects), ER 1165-2-130 (Federal Participation in Shore Protection) and other applicable guidance and regulations. The guidelines for planning water and related land resources activities as contained in the Civil Works Planning Guidance Notebook, require that Federal water resources activities be planned for achieving the National Economic Development (NED) objective. The NED objective is to increase the value of the Nation's output of goods and services and improve national economic efficiency, consistent with protecting the Nation's environments pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements.

3. Due to the level of detail included in the engineering appendix, and the fact that construction of the proposed project is not complex, a General Design Memorandum (GDM) should not be required. Therefore, it is expected that this study will progress directly into the Plans and Specifications (P&S) phase.

STUDY AUTHORITY

4. The New Jersey Shore Protection Study was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987.

5. The Senate resolution adopted by the Committee on Environment and Public Works on December 17, 1987 states:

> "that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hearby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and

processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response".

6. The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

"That the Board of Engineers for Rivers and Harbors is hearby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, the development of recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response which is engineeringly, economically, and environmentally feasible".

STUDY PURPOSE AND SCOPE

7. The Feasibility Study is the second of the Corps of Engineer's two-phase planning study process. The objective of the Feasibility Study is to investigate and recommend solutions to problems identified in the Reconnaissance Study and further defined herein. The Feasibility Report will accomplish the following:

a. Provide a complete presentation of the study results and findings;

b. Indicate compliance with applicable statutes, executive orders and policies; and

c. Provide a sound and documented basis for decision makers at all levels to judge the recommended solution(s).

8. This report presents the results of the analysis of existing conditions, without project conditions, plan formulation and design of the NED plan for the feasibility level study conducted pursuant to the previously mentioned resolutions. The Absecon Island interim study area was investigated to determine the magnitude, location and effect of the shoreline erosion problems. This will form the basis for Federal actions and programs to provide shoreline protection or to provide up-to-date information for state and local management of this coastal area. Specific to Absecon Island, this feasibility report will detail the following:

a. Define problems and opportunities in each problem area, and identify potential solutions,

b. Identify costs, environmental and social impacts, and economic indicators of identified potential solutions,

c. Present the recommended optimized NED plan for each problem area, and,

d. Present the Project Cooperation Agreement (PCA) responsibilities of the non-Federal sponsor.

STUDY AREA

9. The study area is located in southern New Jersey and is approximately 8 miles in length, extending from Absecon Inlet to Great Egg Harbor Inlet as seen in Figure 1. The study area encompasses Absecon Island, which is located in Atlantic County. Atlantic County consists of 23 incorporated communities and over 50 unincorporated communities.

10. Absecon Island contains the four communities of Atlantic City, Ventnor, Margate, and Longport. This island fronts the Atlantic Ocean on its southeastern length, Absecon Inlet along its northeastern inlet frontage and has extensive coastal and estuarine wetlands on its western boundary.

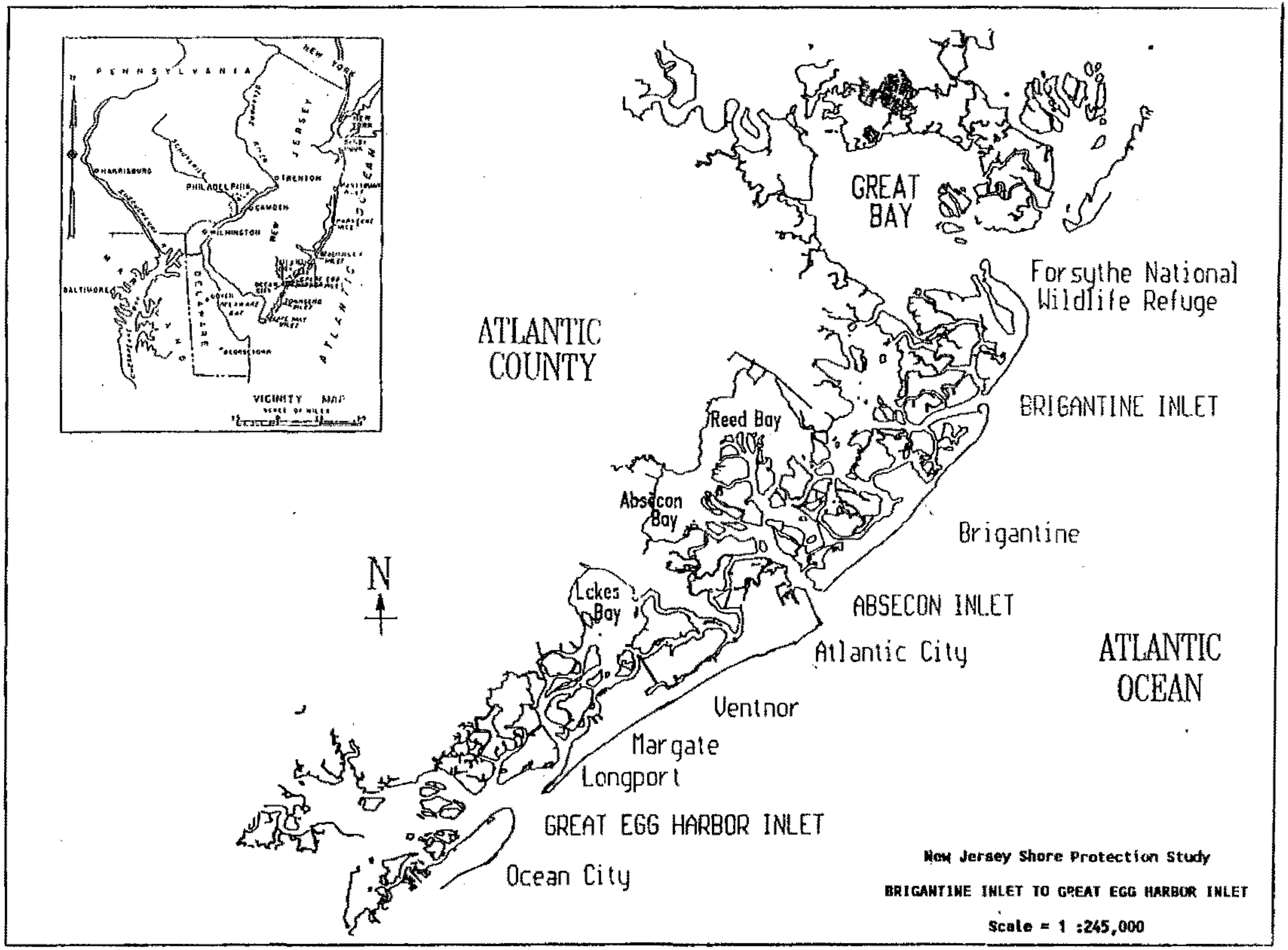


Figure 1 Brigantine Inlet to Great Egg Harbor Inlet Study Area

PRIOR STUDIES, REPORTS AND RELATED PROJECTS

11. There exist numerous planned, ongoing and completed shoreline programs and projects for the New Jersey coast. The work has been initiated by various groups including the Federal government, the State of New Jersey, municipalities, and private interests. The description and status of these projects and studies follow.

12. FEDERAL. The history of Corps involvement in the New Jersey Coast is long and intricate. Before 1930, Federal government involvement in shore erosion was limited to protection of public property. With the enactment of The River and Harbor Act of 1930 (Public Law 71-520, Section 2) the Chief of Engineers was authorized to make studies of the erosion problem in cooperation with municipal and state governments in order to devise a means of preventing further erosion of the shores. Until 1946, the Federal aid was limited to studies and technical advice. In that year, and again in 1956 (PL 84-826) and 1962 (PL 87-874), the law was amended to provide Federal participation in the cost of a project and allowed limited contribution to the protection of privately owned shores which would benefit the public. Table 1 describes recent Federal projects within the study limits.

13. The Federal navigation project at Absecon Inlet provides for an entrance channel 20 feet by 400 feet through the inlet and an entrance channel 15 feet deep with a turning basin in Clam Creek (see figure 9 later in this report).

14. Two early Federal beach erosion control projects in the study area include the Atlantic City, NJ project and the Ventnor, Margate and Longport, NJ project. The Atlantic City project was adopted as House Document 81-538 in 1954 and modified in HD 88-325 in 1962 and again in 1965. Along the Absecon Inlet frontage, the Atlantic City project included replacement of a damaged concrete seawall with a steel sheet piling wall; construction of the Brigantine Jetty; construction and extension of groins; placing revetment at the toe of an existing bulkhead; extension of the Oriental Avenue Jetty; and widening the Absecon Inlet navigation channel and maintaining this relocation by utilizing borrow material from the east side of the channel to widen the beaches along the inlet frontage. Along the ocean frontage the project included construction and extension of groins, beachfill, and periodic nourishment for a period of ten years. The project has been partially completed to include 3727 feet of the Brigantine Jetty, some groin and bulkhead work, and beachfill. The project was deauthorized on 1 January 1990 by PL 99-662.

15. The Ventnor, Margate, and Longport, NJ project was authorized by PL 86-645. This project was later modified by section 103 of the River and Harbor Act of 1962 (PL 87-874) and consists of widening 5,500 feet of beachfront, maintenance of an existing groin and periodic nourishment for a period of ten years. This project was deferred in November 1971 due to consideration of the Absecon Island project recommended in the comprehensive New Jersey Coastal Inlets and Beaches Study. The project was deauthorized on 1 January, 1990 by PL 99-662.

16. The Corps of Engineers conducted several beach erosion control and navigation studies during the 1960's and 1970's under the New Jersey Coastal Inlets and Beaches Study. The following

separate projects were included in the Barnegat Inlet to Longport House Document 94-631:

i. Barnegat Inlet
ii. Long Beach Island
iii. Brigantine Island
iv. Absecon Island

17. These projects were authorized for Phase I Design Memorandum Stage of Advanced Engineering and Design by section 101a of WRDA 1976. The projects in the study area, Brigantine Island and Absecon Island, were reauthorized pursuant to the provision of Section 605 of the Water Resources Development Act of 1986. The project for Brigantine Island includes beachfill, dunes, groins and periodic nourishment. The Absecon Island project included all features pertinent to the Absecon Inlet frontage from the Atlantic City project described above, a weir breakwater north of the Brigantine jetty, and beachfill and periodic nourishment along the oceanfront beaches. Neither of these projects have been completed however, because of the large cost associated with hard shore protection structures, and due to the predominance of recreation benefits in the original formulation. Recreation benefits are no longer a high priority output of Federal projects.

18. As stated above, section 605 of WRDA 1986 authorized the four separable projects from Barnegat Inlet to Longport, NJ. Each of the Beach Erosion Control projects had predominant recreation benefits and therefore PED was never initiated. The Barnegat Inlet project modification was constructed as a design deficiency under the authority of the Supplemental Appropriations Act of 1985 (PL 99-88) and the project's original authorization, which was the Rivers and Harbors Act of 1935 (as referred to in the executed Local Cost Sharing Agreement). Accordingly, since the authority of section 605 of PL 99-662 has not been used for funding for either PED or construction, and since section 1001 of that act deauthorizes any unfunded project authorized in WRDA 86 within five years of the date of enactment, the projects for Barnegat Inlet to Longport, NJ are considered deauthorized as of 17 November, 1991.

19. The New Jersey Shore Protection Study was initiated to investigate shoreline protection and water quality problems which exist along the entire coast. A common thread is the physical coastal processes which affect both. Physical coastal processes are those mechanisms occurring in the coastal zone which result in the movement of water, and littoral materials. It was demonstrated that existing numerical data were insufficient to formulate long term solutions, especially in the vicinity of inlets, with confidence.

20. The Limited Reconnaissance Phase of the New Jersey Shore Protection Study identified and prioritized those coastal reaches which have potential Federal interest based on shore protection and water quality problems which can be addressed by the Corps of Engineers (COE). The limited reconnaissance study report was completed in September 1990, and recommended that a reconnaissance phase study be conducted.

21. Federal funds were allocated in 1991 to conduct a reconnaissance study of the Brigantine Inlet to Great Egg Harbor Inlet reach. The Reconnaissance Study was completed in 1992. Findings

indicated that there was Federal interest in providing shore protection to Absecon Island and therefore the report recommended that the necessary planning and engineering studies proceed to the cost shared feasibility study.

22. Subsequently, the Feasibility Cost Sharing Agreement was signed and the study initiated in March 1993. The Absecon Island Interim Study is scheduled to be complete in December 1996. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal cost sharing sponsor.

TABLE 1
PRIOR FEDERAL ACTIONS
BRIGANTINE INLET TO GREAT EGG HARBOR INLET

AGENCY	LOCATION	AUTHORIZATION	DESCRIPTION OF PROJECT/STUDY	STATUS
USACE	Brigantine Inlet to Great Egg Harbor Inlet	Senate and House Resolutions December 1987	Shore Protection and Water Quality Study	Reconnaissance Study Report February, 1992
USACE	Coast of New Jersey, Sandy Hook to Cape May	Senate and House Resolutions December 1987	Shore Protection and Water Quality Study	Limited Reconnaissance Study Report September, 1990
USACE	Brigantine Island	HD 94-631 SEC 101a-WRDA 1976 SEC 605-WRDA 1986	Reimburse State for 7 groins Construct new groin Construct dune with fence & grass Raise beach Extend groin Maintain existing groins Periodic nourishment	Preconstruction Planning/Engineering funds never appropriated.
USACE	Absecon Island	HD 94-631 SEC 101a-WRDA 1976 SEC 605-WRDA 1986	Construct weir breakwater for sand bypassing Initial nourishment of beaches Periodic nourishment of beaches	Preconstruction Planning/Engineering funds never appropriated.
USACE	Ventnor, Margate, Longport	PL 86-645. Modified PL 87-874, 1962	Widen beach by placement of fill Maintenance of one existing groin Periodic nourishment	Deauthorized 1 Jan 90 by PL99-662
USACE	Atlantic City	HD 81-538 of 1954 HD 88-325 of 1962	Inlet frontage seawall New groins and extensions Beachfill and Periodic nourishment	Deauthorized 1 Jan 90 by PL99-662
USACE	Absecon Inlet Clam Creek	HD 67-375 of 1922 HD 76-504 of 1946	Provide entrance channel	Completed 1957; Last maintenance dredging 1978 Clam Creek dredged 1983

23. STATE. The State of New Jersey has been involved in providing technical and financial assistance to its shore towns for decades. The State officially tasked the Department of Environmental Protection (formerly The Dept. of Conservation and Economic Development) to repair and construct all necessary structures for shore protection in the early 1940's (N.J.S.A. 12:6A-1). An annual appropriation of one million dollars was established and maintained until 1977. Due to extensive destruction and erosion of the shoreline from frequent severe storms, an additional $30 million was appropriated in 1977. In addition to initiating their own research and construction efforts, the State of New Jersey also cost-shares portions of many Federal projects. In 1988 the State of New Jersey funded the COE to perform economic benefit reevaluation studies of the Federally authorized Brigantine Island and Absecon Island projects. This reevaluation determined that the previously authorized projects were still justified utilizing current COE procedures, methodologies and policy priorities.

24. The NJDEP has been involved in various areas of local shore protection along the coast of New Jersey. The Division of Coastal Resources provides technical assistance to citizens, municipalities, etc. Further, it regulates land use through the Coastal Zone Facility Review Act (CAFRA), the Wetlands Act, and the Waterfront Development Act.

25. In 1978, the legislature passed a Beaches and Harbors Bond Act (P.L., 1978, c.157) and instructed the NJDEP to prepare a comprehensive Shore Protection Master Plan in order to reduce the impacts and conflicts between shoreline erosion management and coastal development. Released in 1981, it has served as a guide to suitable alternatives for the mitigation of erosion and to develop a list of priorities among the engineering plans. Efforts were begun in 1995 to revise the Master Plan.

26. After the Halloween Storm of 1991 devastated New Jersey's shoreline, $15 million was appropriated as an amendment to the State's Economic Recovery Fund for Shore Protection. Soon thereafter, the January 1992 storm struck, overwhelming the State's fiscal resources and prompting a Presidential Disaster declaration.

27. The issue of providing stable funding for shore protection at the State level had been raised on several occasions. The two storms during the winter of 1991-92 prompted a Governor's Shore Protection Summit in February of 1992. As a result, the Shore Protection and Tourism Act of 1992 was passed which created the first ever stable source of funding for shore protection of at least $15 million annually.

28. Since 1985, the New Jersey Department of Environmental Protection has initiated several projects in the study area. Many projects involve dredging of navigation channels and discharging the material on beaches or in back bays. All of the projects under the authority of the State are tailored to address specific small scale problems and are therefore less expensive than Federal shore protection and navigation projects.

29. One such notable project is the construction of a stone revetment along Great Egg Harbor Inlet at the southern end of Longport in the fall of 1993. In response to erosion of the beach south of the 11th Avenue groin, the existing revetment was rehabilitated with 8 to 9 ton weight rough

quarrystone. The new revetment has a top width of 14 feet, a top elevation of +8.0 MLW. For more information see the Erosion Control Structure Inventory section of this report.

30. MUNICIPAL. Municipalities along the coast of New Jersey have adopted various plans in response to coastal erosion. Shore protection regulations, such as dune management are often left to the municipalities. Most municipal shore protection involvement concerns land management policies and small erosion mitigation efforts.

31. Since 1985, three larger-scale municipal improvement projects have been constructed in the study area. In the aftermath of the December 1992 storm, the Borough of Longport placed additional large stone along their back bay shoreline to reduce flooding and wave attack. The City of Atlantic City reconstructed portions of the bulkhead along Absecon Inlet. This new bulkhead is fronted by two to three ton riprap for toe protection.

32. During the summer of 1995, Atlantic City installed approximately 6000 feet of 6' X 12' woven polypropolene geotubes along portions of the oceanfront. When filled with sand, the geotubes act as the core of a dune which protects the boardwalk and other beachfront structures. For more information see the Erosion Control Structure Inventory section of this report.

33. PRIVATE. A great deal of private interest projects have taken place along the New Jersey Coast in recent years. Like municipal projects, all private ventures which take place in navigable waters of the United States and/or involve the placement of fill or structures in wetland areas must be approved by the U.S. Army Corps of Engineers.

34. Private interests are generally involved in small projects which directly affect their coastal property. In recent years, a great deal of marina and bay development activities have taken place. This is a very strong indictor of the increase in population and land use along the coastline of New Jersey. Unfortunately, because of the sporadic nature of private development, little is known regarding the interrelation and effects these small projects have on coastal processes.

RELATED INSTITUTIONAL PROGRAMS AND COORDINATION

35. Study efforts have been coordinated with agencies and organizations involved in New Jersey coastal problems including the US Environmental Protection Agency (USEPA), the Federal Emergency Management Agency (FEMA), the National Oceanographic and Atmospheric Administration (NOAA), New Jersey Department of Environmental Protection (NJDEP), New Jersey Shore and Beach Preservation Association, US Fish and Wildlife Service, Rutgers University, Lehigh University, Drexel University, Stockton State College, Atlantic County Planning Board, and the Corps' Coastal Engineering Research Center.

36. Complementary work includes coastal water quality monitoring of Atlantic County by the Atlantic County Department of Health. This work is being performed in cooperation with NJDEP. The New Jersey Beach Profiling Network instituted by NJDEP and carried out by Stockton State

College provides yearly profiles for several areas in the study area. These efforts represent an important addition of information to the Philadelphia District's studies of shoreline protection and water quality.

EXISTING CONDITIONS

SOCIO-ECONOMIC RESOURCES EVALUATION

37. DESCRIPTION OF THE STUDY AREA. Absecon Island is comprised of four communities; Atlantic City, Longport, Margate and Ventnor, all of which are located within Atlantic County's 565 square miles. The study area is bordered by Absecon Inlet to the north and Great Egg Harbor Inlet to the south.

38. Atlantic County is the 6th least populated county within New Jersey with a total population of 224,327 year round residents in 1990, equalling only 2.5% of the state's permanent population. Although Atlantic County covers 565 square miles, approximately three-quarters of the residents live within five miles of the ocean. Early development along these beach front communities are currently causing slow growth trends to occur within the study area's boundaries. Despite these slow growth rates, over 85% of seasonal residents in Atlantic County are concentrated in the island communities of Atlantic City, Brigantine, Longport, Margate, Ventnor and the backbay communities of Absecon, Linwood, Northfield and Somers Point.

39. These communities rely heavily on the tourist industry for their economic stability. Although South Jersey is largely responsible for supporting the "Garden State" image, 62.9% of Atlantic County residents depend on service and sale oriented companies while only 0.42% of the work force is employed in farming, fishing or forestry.

40. <u>Atlantic City</u>. Within the county, Atlantic City is the most heavily developed community with a population of 40,199 year-round residents in 1980 and 3,347.71 people per square mile accounting for 2/3 of the study area's population. Between 1980 and 1990 however, Atlantic City experienced a decline of 5.6% lowering the population to 37,986 (see table 2). The population is expected to rise to approximately 40,450 by the year 2000 (see table 3).

41. New development has slowed over recent years. In 1991 only one new privately owned housing unit was authorized by building permits in comparison to the 39 units authorized in 1990. This is largely due to the lack of vacant land as only 6% of the total property was vacant in year 1993. Unlike the majority of the study area, Atlantic City is heavily commercialized composing 76.8% of the tax base with only 14.28% residential. Atlantic City's beaches are primarily lined with commercial buildings such as hotels, casinos, and shops, while Longport, Margate and Ventnor remain mostly residential.

42. The casinos have helped make the Atlantic City boardwalk famous while helping to attract a total of 3.2 million visitors in 1993 alone. Not only have the casinos helped the city bring in needed tourist related jobs, but they have also helped to rebuild the neighboring communities by forming an organization called the Casino Reinvestment Development Authority (CRDA). In conjunction with the CRDA, Atlantic City has planned a $42 million housing rehabilitation program, which began construction in October 1993. The program will provide 198 housing units on a 15 acre track of land

in the Inlet section of Atlantic City. Construction cost per unit is approximately $170,000, however subsidies from the CRDA will allow qualified residents to purchase the townhouses at a selling price between $70,000 and $80,000 placing it within range of the median value for single homes which was $73,400 in 1990.

43. This development represents the second phase of a $500 million redevelopment of the North-East inlet which is expected to be complete within approximately 10 years. The program will result in 2,500 new or rehabilitated housing units, commercial space and recreational areas. These renovated homes will be a great help to a city that has one of the highest unemployment rates along the Jersey shore. Atlantic City had a median household income of only $20,309 in 1989 and an unemployment rate of 5.5% with 9,208 people living below the poverty line, accounting for almost 25% of the residents.

44. The third phase of the CRDA redevelopment plan involves the construction of low-rise (townhouses) and mid-rise (approximately 100-150 units) residential structures in three tax blocks located along the Inlet frontage. CRDA has acquired the necessary property, performed site remediation, and expects construction to begin in 1996. Another major component of the Inlet renewal effort is the development of the Maine Avenue County Park. The park will extend from the waters edge to New Hampshire Avenue, a recently improved major access road. It will include ample landscaping, a pavilion, and parking area with a cove, and passive waterfront park at the waters edge.

45. The city is also planning to build a new convention center directly off the Atlantic City Expressway, and plans to have a water and amusement ride theme park serve as a gateway corridor between the new convention center and the casinos (Bally's, Caesars, and Trump Plaza). While this new development is largely on the bay, it may impact our study area by bringing more visitors to the beach.

46. Ventnor. To the south of Atlantic City is Ventnor, a resort city with a boardwalk and approximately 1.5 square miles of public beach which nearly 28,000 summer residents came to enjoy in 1993 (ssee table 2). Ventnor's population has also declined over the past decade by approximately 6% to 11,005 in 1990. It is projected that population will continue to decline by 5% until the year 2000 to a total of 10,418 (see table 3).

47. Because of the town's proximity to Atlantic City, Ventnor is also very highly developed, with a total of 5,135 residents per square mile. In 1991 there were only three building permits issued for single family units compared to 27 permits authorized in 1989. The community is primarily residential with only 2 industrial complexes and 141 commercial lots within the city's boundaries.

48. Along the boardwalk are several high rise condominium complexes and hotels. However, traveling south away from Atlantic City, the area becomes more residential with single family homes along the beach-front rather than commercial lots. The median value of a single family home was $137,700 in 1990, almost twice the value of residential homes in Atlantic City.

49. Margate. Bordering Ventnor to the south is Margate. Unlike Ventnor and Atlantic City,

Margate is more of a residential community. Margate encompasses 1.41 square miles of land. Neither Margate nor Longport have boardwalks, however all of their beaches allow public access. The beach front is almost entirely residential with only a few commercial and public buildings, including a senior citizens center and a public library. There are 6,726 total housing units, of which 45% are owner occupied. The median value for single family homes is $176,800 while median rent is $564.

50. Population has consistently declined over the last 30 years from 10,576 permanent residents in 1970 to only 8,431 in 1990 (see table 2). This trend is expected to continue into the year 2010 when it will fall to 7,315 (see table 3).

51. Like all of the cities in the study area Margate is a primarily service oriented labor force. Out of 4,563 civilian employees, 53% are service oriented with only 0.15% in the farming, fishing and forestry industry. The median income per household in 1989 was $40,649 with only 286 residents living below the poverty line (see table 4).

52. Longport. The southernmost town in the study area is Longport which lies between Margate and Great Egg Harbor Inlet. Longport is a small, quiet, residential community. The median age is 58.4 years and more than half of the residents are retired. There are no boardwalks or amusement parks to attract the younger crowd, however there are approximately 1.24 square miles of public access beaches which bring in nearly 6,000 summer residents and 1,224 year-round residents (see table 2).

53. There are 1,537 housing units with a total of 1,058 single family units and 479 multi-family units. The borough is almost completely developed with only 5% of the land remaining vacant for future development. The study area is primarily zoned for residential single family units, however there is one commercial lot and one multi-family unit along Beach Avenue. The median value for a single family home was $201,800 in 1993.

Table 2

POPULATION		
NAME	SUMMER POPULATION[1]	1990 POPULATION[2]
Atlantic County	360,132	224,327
Atlantic City	3.2 million visitors (annually)	37,986
Longport	6,000	1,224
Margate	24,000	8,431
Ventnor	28,000	11,005

Notes:
1 Based on interviews with local officials.
2 The New Jersey Municipal Data Book 1994, consistent with the 1990 Census.

54. The Atlantic County Division of Economic Development projects that Atlantic County population will increase by 9.7% between 1990 and 2000, and by 8.5% between 2000 and 2010. Within Atlantic County Longport, Margate and Ventnor are expected to grow at slow rates, while Atlantic City is expected to experience mild to moderate growth.

Table 3

PROJECTED POPULATION					
	1990	1995	2000	2005	2010
Atlantic County	224,327	233,075	246,153	256,617	267,080
Atlantic City	37,986	38,972	40,450	41,696	42,941
Longport	1,224	1,175	1,102	1,084	1,066
Margate	8,431	8,090	7,578	7,447	7,315
Ventnor	11,005	10,770	10,418	10,411	10,404

Table 4

INCOME FOR 1989				
NAME	PER CAPITA INCOME	MEDIAN HOUSEHOLD INCOME	MEDIAN FAMILY INCOME	PERSONS BELOW POVERTY
Atlantic City	12,017	20,309	27,804	9,208
Longport	23,737	34,464	45,288	107
Margate	27,939	40,649	54,949	286
Ventnor	19,038	33,120	43,414	727

Source: The New Jersey Municipal Data Book 1994 published by the U.S. Census

REAL ESTATE

55. For purposes of this report and consistent with New Jersey riparian law, the shoreline is synonymous with the mean high tide line. Areas upland of this line can be publicly or privately owned while the tidelands are by default owned by the State, unless riparian rights are granted. Easements, flood water retention, and storm damage assessment are principal reasons for determining shoreline ownership in this study, therefore ownership will be defined as the upland beach property which has frontage on the mean high water line.

56. The length of the shoreline for the 4 communities within the study area is approximately 8.3 miles. This total length is subdivided into three ownership categories: Public; which is 57.5 percent of the total length, Private with public access, which is 42.5 percent of the total length and Private with exclusive access which is zero percent. The ownership of beach front property for the cities and boroughs of Absecon Island is shown in Table 6.

57. All beachfront areas are available for access by the general public for recreational purposes. The underlying fee owners of the private areas have the right to restrict, prohibit or deny any commercial enterprises on their property.

TABLE 5
SHORELINE OWNERSHIP FOR
ABSECON ISLAND

LOCATION	TOTAL ft/acreage	PUBLIC ft/acreage	PRIVATE W/Public Access ft/acreage	PRIVATE Exclusive ft/acreage
Atlantic City	17,950/82	4,350/20	13,600/62	0/0
Ventnor	9,000/41	4,800/22	4,200/19	0/0
Margate	8,550/40	8,200/38	350/2	0/0
Longport	8,400/38	7,900/36	500/2	0/0
TOTALS	43,900/201	25,250/116	18,650/85	0/0

58. The municipalities of Atlantic City and Longport are in compliance with the State of New Jersey requirement that public access and easements have been obtained along their shorefronts to enable them to be eligible for grants and/or funding associated with any future shore protection project.

GEOTECHNICAL EVALUATION

59. PHYSIOGRAPHY. The study area lies along the southern coast of New Jersey within the Coastal Plain province of eastern North America. In New Jersey, the province extends from a line through Trenton and Perth Amboy southeastward for about 150 miles to the edge of the continental shelf. The land portion of the province is bounded on the northeast by Raritan Bay and on the west and south by the Delaware Estuary. The submerged portion of the plain slopes gently southeastward at 5 or 6 feet per mile for nearly 100 miles to the edge of the continental shelf. The surface of the shelf consists of broad swells and shallow depressions with evidence of former shore lines and extensions of river drainage systems. The most prominent of these valleys is the Wilmington Canyon, which is an extension of the Delaware River drainage system off the southern portion of the New Jersey coast. The Atlantic coastal shelf is essentially a sandy structure with occasional silty or gravelly deposits. It extends from Georges Bank off Cape Cod to Florida, and it is by far the world's largest sandy continental shelf.

60. About 85 percent of the shorefront of New Jersey consists of a chain of narrow barrier beaches with elevations generally less than 20 feet above sea level. These beaches, each of which is a minimum of 7 miles in length, are separated from each other by ten tidal inlets. The remaining shorefront areas are where the sea directly meets the mainland; this occurs in a 19-mile reach of the northern and a 3-mile reach of the southern end of the New Jersey coast.

61. The New Jersey barrier beaches belong to a land form susceptible to comparatively rapid changes. Between the barrier beach and the mainland, there is an expanse of tidal marshland and water areas approximately 3 to five miles wide. The water areas include tidal lagoons or sounds, and a network of winding thorofares draining the marshland.

62. The drainage system of the New Jersey coastal plain was developed at a time when sea level was lower than at present. The subsequent rise in sea level has drowned the mouths of coastal streams. The formation of the barrier beaches removed all direct stream connection with the ocean between Barnegat Bay and Cape May. These streams now flow into lagoons formed in back of the barrier beach and their waters reach the Atlantic Ocean by way of the tidal inlets through the barrier beaches. The significance of these features of the drainage system to the problem area is that the coastal plain streams, which carry little sediment in their upper courses, lose that sediment in the estuaries and in the lagoons, and thus supply virtually no beach nourishment to the ocean front.

63. SURFICIAL DEPOSITS. The entire portion of the coastal plain draining to the study area is a sedimentary feature that developed under essentially the same set of conditions for a considerable period of geologic time. The area is capped with almost entirely unconsolidated sediments of Tertiary or more recent deposition. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May formation, consisting largely of sand and gravel, was deposited during the last interglacial stage when sea level stood 30 to 40 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shore line. These deposits now stand as terraces along portions of the coast and form the mainland bluff at Cape May. The barrier beaches being of relatively recent origin are composed of the same material as the offshore bottom.

64. SUBSURFACE GEOLOGY. The Atlantic coastal plain consists of sedimentary formations overlying a crystalline rock mass known as the "basement". From well drilling logs it is known that the basement slopes at about 75 feet per mile from the Fall Line to a depth of more than 6,000 feet near the coast. Geophysical investigations have corroborated these findings and have permitted determination of the profile seaward to the continental slope. A short distance offshore, the basement surface drops abruptly but rises again gradually as the continental slope is approached. Overlying the basement are semi-consolidated beds of lower Cretaceous sediments. These beds vary greatly in thickness, increasing seaward to a maximum thickness of 13,300 feet then decreasing to 8,900 feet near the edge of the continental shelf. On top of the semi-consolidated material lie unconsolidated sediments of Upper Cretaceous and Tertiary formations. These materials, in relatively thin beds on the land portion of the coastal plain, increase in thickness to a maximum of 4,800 feet near the edge of the continental shelf.

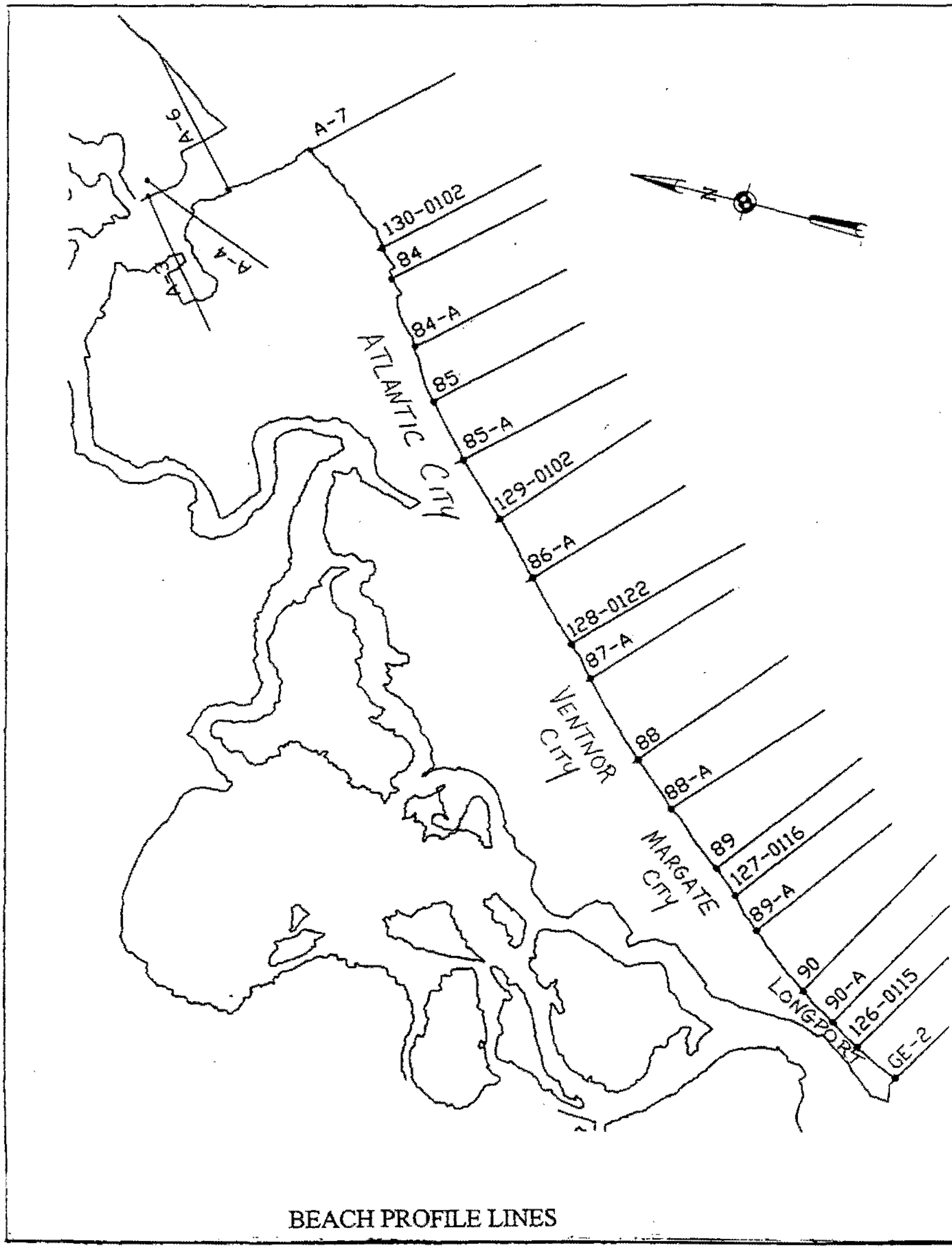
SELECTION OF BORROW MATERIAL

65. OFFSHORE BORROW AREA INVESTIGATION. The Reconnaissance Study report identified

several possible borrow areas for Absecon Island. In order to specifically identify sources of sand for the Absecon Island feasibility study, a series of 15 vibracores was done. The vibracores were collected by Alpine Ocean Seismic Survey, Inc. in the Atlantic Ocean off of the coast of New Jersey. The samples were collected between 12 October and 27 October 1993. The desired depth of penetration for the vibracores was 20 feet. The field work included positioning of the vessel using a DGPS navigational system, obtaining continuous core samples and obtaining penetrometer records. The field work was conducted aboard the "Atlantic Surveyor", a 110 foot offshore supply boat. The vibracores were retrieved using a model 271B Alpine pneumatic vibracorer, with an air-driven vibratory hammer. The field work was periodically inspected by Philadelphia District personnel. Sieve analysis of the sediment retrieved in the vibracores was conducted by the Army Corps of Engineers South Atlantic Division Laboratory (SAD Lab).

65a. Through the use of maps and charts which show offshore bathymetry, plans and specifications records for previous beachfill jobs, literature which included vibracore logs from previous investigations, and coordinates for overboard disposal areas of dredged material, the three proposed borrow areas in this report were identified. The three area identified as potential borrow sites include all of the sites where large deposits of sand can be found. Identification of additional sites would entail relatively large areas of potentially shallow bedded areas, resulting in the widespread disturbance of surf clam habitat, which is unacceptable to the environmental interests. The Absecon Inlet borrow area was initially identified since portions of this area had been mined previously for beachfill. The Great Egg Harbor Inlet borrow area was initially identified due to the fact that a portion of the ebb shoal was already in use supplying high-quality beachfill material for Ocean City, N.J. The offshore borrow area was initially identified as a bathymetric feature (a shoal) which would probably contain suitable beachfill material. The vibracores were then conducted for these areas to obtain sediment samples for testing and suitability analysis. The vibracore samples verified the suitability of sand within these three borrow areas for use as beachfill material for Absecon Island. All three borrow areas were then designated as possible borrow sites for the Absecon Island project. Once these areas were identified as sources of suitable beachfill material, environmental and cultural investigations were completed. The environmental field investigations consisted of benthic sampling and tows for surf clams. The results of these investigations indicated that the use of Absecon Inlet borrow area would reduce the impacts to benthic and surf clam resources, as the offshore area and Great Egg Harbor Inlet area have much higher densities of surf clams. To further lessen any impacts to surf clams, the size of the Absecon Inlet borrow area was curtailed and it was decided that the initial quantity of sand and the first few nourishment cycles would utilize this borrow site.

66. Beach Sampling. Two sets of beach samples were obtained on eight survey lines along the ocean coast of Absecon Island (see figure 2). Not all survey lines were designated for beach sampling. A distance of approximately one mile was used to determine the spacing between survey lines that were to be sampled. The survey lines that were sampled are as follows: A-7, 84-A, 129-0102, 87-A, 88-A, 89-A, 90-A and GE-2. Beach samples for both sets of sampling were collected at the following locations along each survey line: dune base, mid-berm, mid-beach, berm crest, low tide, -6 MLW, -12 MLW, and -18 MLW.



A-7
A-6
A-4
A-3
130-0102
84
84-A
85
85-A
129-0102
86-A
128-0122
87-A
88
88-A
89
127-0116
89-A
90
90-A
126-0115
GE-2
ATLANTIC CITY
VENTNOR CITY
MARGATE CITY
LONGPORT
N
BEACH PROFILE LINES

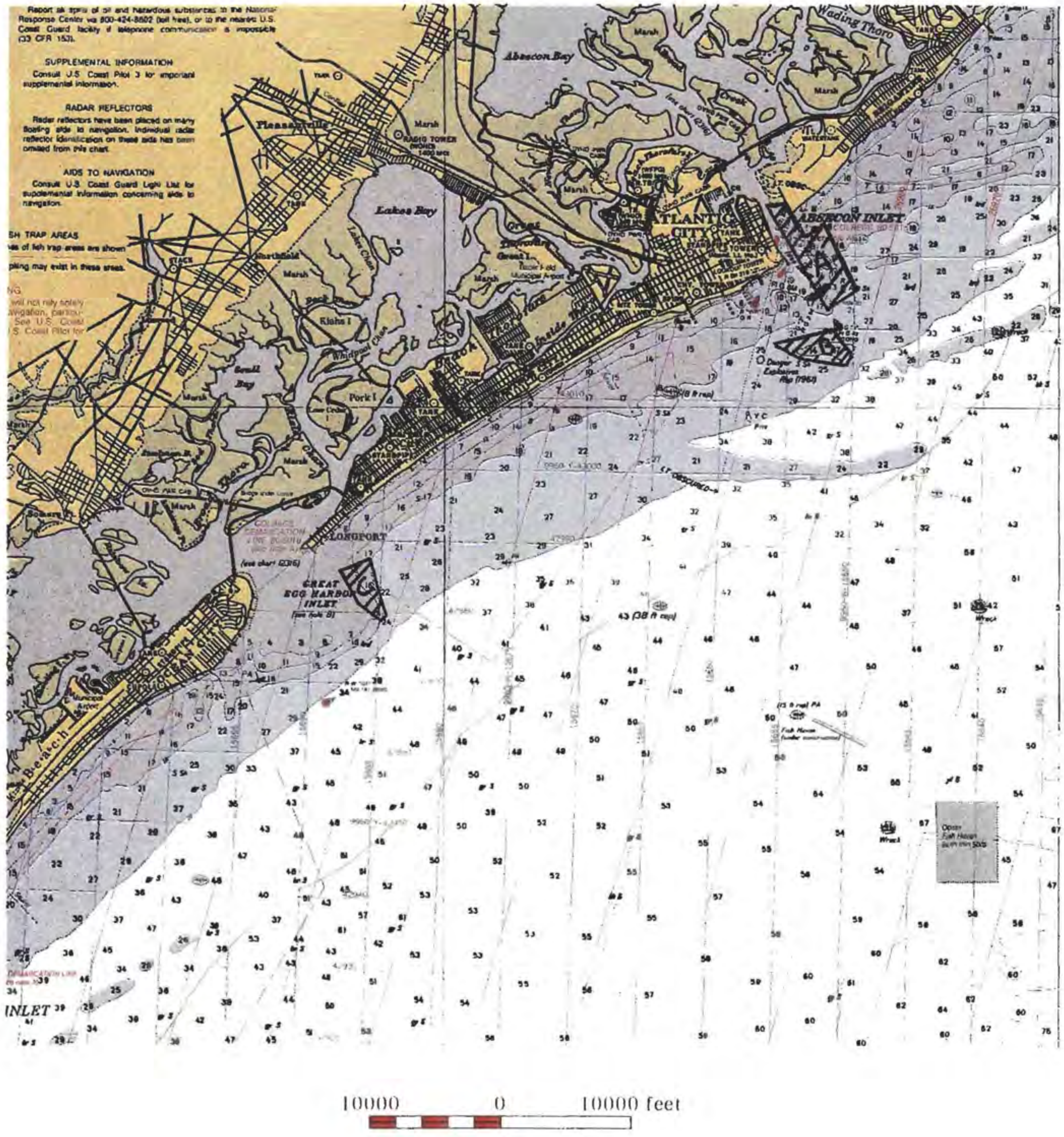
Figure 2

33

67. Borrow Area Investigation and Identification. Vibracore borings for borrow area identification were done in three specific locations. The first location was Absecon Inlet, the second location was offshore of Atlantic City, and the third location was Great Egg Harbor Inlet.

68. Vibracore Borings. The results of the vibracore investigation and analysis indicate that three potential borrow areas exist for Absecon Island (see figure 3). The first potential borrow area is the northern portion of Absecon Inlet. The second potential borrow area lies approximately 1 to 1-1/4 miles offshore of Atlantic City. The third area lies on a portion of the northern half of the Great Egg Harbor Inlet ebb shoal. All areas contains large quantities of fine sand as identified by the sieve analysis conducted by the SAD Lab.

Absecon Island Borrow Areas



Absecon Island Borrow Areas

Figure 3

69. Borrow Area Suitability Analysis. Ideally, borrow material should be the same size, or slightly coarser than the native material on the beach to be nourished. If the borrow material has a significantly smaller grain size, the profile will be out of equilibrium with the local wave and current environment, and will therefore be quickly eroded either offshore or alongshore. This analysis compares the native sediment characteristics to the borrow material characteristics. The analysis was completed using the methodology put forth in the Shore Protection Manual. Overfill factors (Ra) and renourishment factors (Rj) were calculated for each potential borrow area. The overfill factor estimates the volume of fill material needed to produce one cubic yard of stable beach material after equilibrium (when the beach and native materials are compatible) is reached. Consequently, overfill factors are greater or equal to one. For example, an overfill ratio of 1.2 would indicate that 1.2 cubic yards of borrow material would be required to produce 1.0 cubic yards of stable beach material. This technique assumes that both the native and composite borrow material distributions are nearly log-normal. The renourishment factor is a measure of the stability of the placed borrow material relative to the native beach sand. Desirable values of the renourishment factor are those less than or equal to one. For example, a renourishment factor of 0.33 would mean that renourishment using the borrow material would be required one third as often as renourishment using the same type of material that is currently on the beach.

70. Native Beach Characteristics. A composite beach grain size curve was developed for Absecon Island. The native mean grain size for Absecon Island is 2.36 phi units (0.19 mm) and the standard deviation in phi units is 0.82. This corresponds to a poorly graded or well sorted fine to medium sand. The following tables summarize the results of the grain size analysis including overfill and renourishment factors. The native beach conditions of a mean grain size of 2.40 phi units (0.19 mm) and a standard deviation in phi units of 0.79 were used in determining the factors. These values represent all of the beach samples with the exception of survey line A-7, which was located at the Oriental Avenue jetty and was characterized by much coarser material than was found over the rest of the island.

Table 6

NORTHERN PORTION OF THE GREAT EGG HARBOR EBB SHOAL (LONGPORT)

Vibracore	**Mean Grain Size in phi (Mϕ)**	**Standard Deviation in phi (σϕ)**	**Overfill Factor (Ra)**	**Renourishment Factor (Rj)**
NJV-135	2.86	0.88	2.0	1.7
NJV-136	3.18	0.71	8.0	3.0
NJV-138	3.42	0.58	Unstable	
NJV-139	3.05	0.76	4.0	2.5
NJV-135, 136, 138, and 139 Composite	3.13	0.77	5.0	2.8
NJV-135, 138, and 139 Composite	3.11	0.79	4.1	2.8
NJV-135, 138, and 139 Composite w/only Longport Beach Characteristics	2.86	0.88	1.7	1.6

Table 7
ABSECON INLET

Vibracore	Mean Grain Size in phi ($M\phi$)	Standard Deviation in phi ($\sigma\phi$)	Overfill Factor (Ra)	Renourishment Factor (Rj)
NJV-140	1.33	1.34	1.0	0.1
NJV-143	1.61	1.70	1.1	0.1
NJV-145	3.03	0.56	Unstable	
NJV-146	2.65	0.90	1.3	1.1
NJV-140, 143, 145, and 146 Composite	2.01	1.68	1.2	0.1
NJV-143, 145, and 146 Composite	2.24	1.72	1.4	0.1

Table 8
OFFSHORE OF ATLANTIC CITY

Vibracore	Mean Grain Size in phi ($M\phi$)	Standard Deviation in phi ($\sigma\phi$)	Overfill Factor (Ra)	Renourishment Factor (Rj)
NJV-147	3.19	0.66	Unstable	
NJV-148	2.94	0.74	3.6	2.1
NJV-149	3.28	0.78	7.0	3.1
NJV-150	2.99	0.88	3.0	2.0
NJV-151	2.72	0.92	1.7	1.4
NJV-152	2.59	0.87	1.2	1.2
NJV-148, 151, and 152 Composite	2.76	0.86	1.6	1.4

71. Based on the information presented in the tables above, it appears that a borrow area in Absecon Inlet (NJV-143, 145 and 146) could provide compatible sand with the least amount of overfill (Ra=1.4) and the longest renourishment cycle (Rj=0.1). Another potential borrow area is located approximately 1 to 1 1/4 miles offshore of Atlantic City (cores NJV-148, 151 and 152). However, the use of this borrow area would require a larger amount of overfill (Ra=1.6) and would have a more frequent renourishment cycle (Rj=1.4) than the Absecon Inlet borrow area. Using the Great Egg Harbor Ebb shoal for beach fill (NJV-135, 138 and 139) would also require a larger amount of fill than from the Absecon Inlet borrow area, however, this borrow area would be suitable to fill the Longport area (Ra=1.6 and Rj=1.4).

72. The Absecon Inlet borrow area is approximately 345 acres in size and is estimated to contain approximately 8.5 million cubic yards of sand. The borrow area offshore of Atlantic City is 218 acres in plan view and contains approximately 6 million cubic yards of sand. The Longport borrow area is approximately 190 acres in size and is estimated to contain approximately 5 million cubic yards of sand.

73. HAZARDOUS, TOXIC AND RADIOACTIVE WASTE ASSESSMENT. In accordance with ER 1165-2-132 entitled Hazardous, Toxic and Radioactive Wastes (HTRW) Guidance for Civil Works Projects, dated 26 June, 1992, the Corps of Engineers is required to conduct investigations to determine the existence, nature and extent of hazardous, toxic and radioactive wastes within a project impact area. Hazardous, toxic and radioactive wastes (HTRW) are defined as any "hazardous substance" regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq, as amended. Hazardous substances regulated under CERCLA include "hazardous wastes" under Section 3001 of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 et seq; "hazardous substances" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, "hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412, and "imminently hazardous chemical substances or mixtures" that EPA has taken action on under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606.

74. Land Use, Topography. About 85 percent of the shorefront of New Jersey consists of a chain of narrow barrier beaches with elevations generally less than 20 feet above sea level. These beaches, each of which is approximately 7 miles in length, are separated by ten inlets. The remaining shorefront from Long Branch to Bay Head and that at Cape May Point Point, is mainland of much earlier origin than the barrier islands.

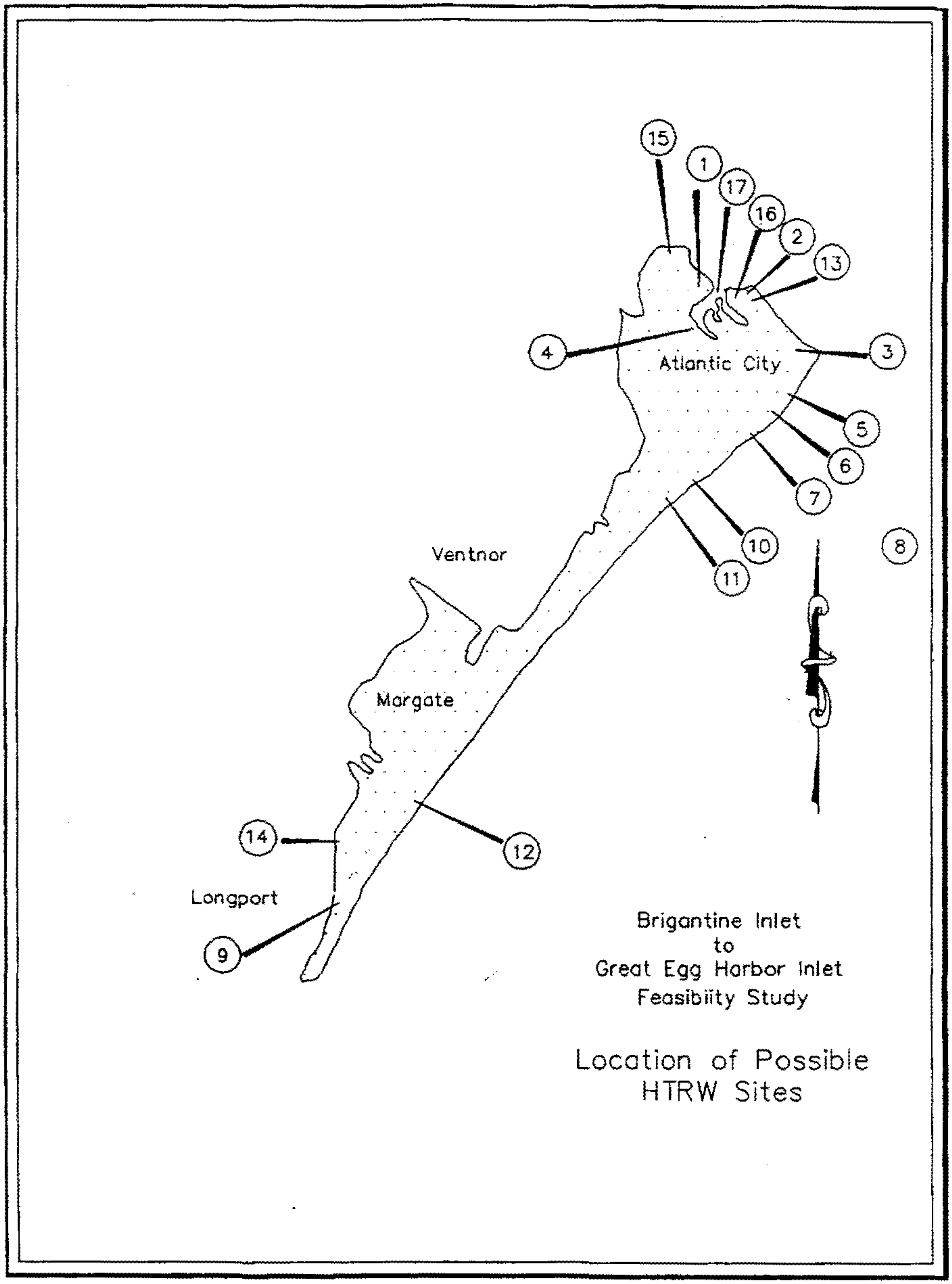
75. The study area consists of the Absecon Island which is a barrier island and is bounded by Absecon Inlet to the north and Great Egg Harbor Inlet to the south. The island contains the four communities of Atlantic City, Ventor, Margate and Longport. Atlantic City is arguably the most heavily developed city on the New Jersey coast. The beachfront in Atlantic City is occupied by extensive commercial development along a world famous boardwalk. Primary among the development are the multimillion dollar casinos. The remainder of Absecon Island is also highly developed but with more standard residential and commercial establishments generally found in a beach community.

76. Preliminary Assessment. An HTRW literature search was conducted for Absecon Island by HRP Associates, Inc. for the U.S. Army Corps of Engineers Philadelphia District. The literature search identified 17 documented or potential HTRW sites in the project area, all located on Absecon Island. The 17 sites are listed below (see figure 4 for approximate locations):

	SITE	Potential/Documented HTRW
1)	U.S. Coast Guard Station	UST Leak
2)	Captain Starn's Pier	UST Leak
3)	Vacant Lot	UST Leak
4)	American Oil Company	Oil Terminal
5)	World International Hotel	UST Leak
6)	Resorts Hotel & Casino	UST Leak
7)	World Lafayette Hotel	UST Leak
8)	Offshore Area	Documented OEW Area
9)	Longport Marine	Ground Water Pollution
10)	Caesar's Hotel & Casino	UST Leak
11)	Bally's Casino	UST Leak
12)	Religious Retreat House	UST Leak
13)	Curtis Aero Station	Former Plane Repair Facility
14)	Longport Shell Gas Station	UST Leak
15)	Harrah's Marina	Ground Water Pollution
16)	Atlantic City & Shore R.R.	Former Train & Bus Repair Facility
17)	Clam Creek	Reported Fuel Spills

77. The preliminary assessment was divided into two sections. Both sections independently evaluated the impacts of the 17 potential HTRW sites listed above. The first section discusses the impacts of the sites on potential offshore borrow areas. The second section evaluates the impacts of the sites on construction which requires excavation (for example, bulkhead replacements, outfall extensions and groin construction) that may take place on Absecon Island itself.

78. Potential for Borrow Area Contamination. Three potential offshore borrow areas have been identified for Absecon Island. These three borrow areas are Absecon Inlet, a linear shoal offshore of Atlantic City, and the northern portion of Great Egg Harbor ebb shoal. A number of the sites listed above can be eliminated due to the fact that 1) there are hydraulic "disconnects" between the mainland and the borrow area (channels, inlets and general topography) and 2) no driving heads to propagate the spread of contamination. The conclusion that groundwater is not a vehicle for contaminant transport into the borrow areas can be drawn. As such, the above sites where groundwater is the main method of contaminant transport can be eliminated (all sites except 8 and 17).


15
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17
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Atlantic City
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8
11
Ventnor
Margate
14
12
Longport
9
Brigantine Inlet
to
Great Egg Harbor Inlet
Feasibiity Study
Location of Possible
HTRW Sites

Figure 4

79. The borrow area in Absecon Inlet is proximal to 17 - reported fuel spills in Clam Creek. The method for contaminant transport in this instance would be the tide and currents. The sediments in the borrow area are recent and are continually reworked by the offshore environment. As such it is not believed that fuel spills in Clam Creek could have any significant impact on the sediment in Absecon Inlet.

80. Lastly, the linear shoal offshore of Atlantic City is proximal to the reported location of the ordnance-explosive waste site (8). In 1961, and at this location, the U.S. Navy lost an undetermined amount of TNT charges in 27 feet of water. However, since the charges are not for underwater use and the borrow area does not intersect the area of concern shown on NOAA chart 12318, site 8, listed above can be eliminated from concern.

81. Potential for Contamination on Absecon Island. A number of potential HTRW sites were documented on Absecon Island. However, all of the sites except one may be eliminated for various reasons.

82. Sites 1, 2, 4, 15 and 16 can be eliminated due to the fact that they are beyond the project's limits. Sites 5, 6, 7, 9, 10, 11, 12, 13 and 14 can be eliminated due to the fact that the recommended plan in proximity to these sites will not include excavation and as such the project would not affect any HTRW. And lastly, sites 8 and 17 can be eliminated due to the fact that they are located offshore and as such will not be affected by landbased construction.

83. Site 3 lies near the location of a new bulkhead on Absecon Inlet, which is proposed in the selected plan. Therefore, site 3, which is curently a vacant lot with a leaking underground storage tank (LUST), was not eliminated from concern. However, excavation in this area will be minimal, especially excavation below the ground water table, which is the medium for contaminant transport in the area. For these reasons, site 3 will not be significantly impacted by a Corps of Engineers project nor will it significantly impact upon a Corps of Engineers project on Absecon Inlet. If necessary, innovative construction methods and other alternatives will be evaluated during preparation of plans and specifications which will ensure that this site will be avoided and that it will not impact the project.

ENVIRONMENTAL RESOURCES EVALUATION

84. AFFECTED ENVIRONMENT. Brigantine and Absecon Islands are separated from the mainland by 3 to 5 miles of shallow bays which include small uninhabited islands, tidal marshes, creeks and lagoons. The ground elevation of the islands is generally no more than 10 feet above mean sea level. Absecon Island is bounded by Absecon Inlet to the north and Great Egg Harbor Inlet to the south. The island contains the four communities of Atlantic City, Ventnor, Margate, and Longport. Both Brigantine and Absecon Islands front the Atlantic Ocean on their eastern boundaries and have extensive coastal and estuarine wetlands on their western boundaries.

85. Absecon Inlet lies between Brigantine Island and Absecon Island and provides a navigable

connection between the Atlantic Ocean and the harbor of Atlantic City and the New Jersey Intracoastal Waterway. The inlet is extensively used by recreational and deep draft commercial craft based behind Atlantic City. It is the most densely developed of the barrier beach islands along the New Jersey coast.

86. Absecon Island, a barrier island which has been heavily developed as a residential and recreational area, is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. A large segment of the lands to the northwest of the barrier island are classified as a backbay/coastal salt marsh system. Brigantine Island is much less developed and is primarily classified as a marine intertidal beach/bar behind which are palustrine emergent, estuarine intertidal and palustrine scrub-shrub wetlands. Common species of the beach and dune area on the barrier island system include beach grass, sea-rocket, seaside goldenrod, poison ivy, groundsel-tree, and marsh elder.

87. The backbays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. The low marsh zone is typically dominated by saltmarsh cordgrass. Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks and other organisms. Dominant species include sea lettuce and eelgrass. The high marsh zone, which is slightly lower in elevation than the transition zone is dominated by saltmeadow cordgrass and salt grass. This zone is typically flooded by spring high-tide. Plants typical of the transition zone include both upland and marsh species including marsh elder, groundsel-tree, bayberry, saltgrass, sea-blite, glasswort, poison ivy, and common reed.

88. WATER QUALITY. Through the State of New Jersey's Cooperative Coastal Monitoring Program, coastal and backbay water quality is monitored by the Atlantic County Health Department and Atlantic City Health Department. Ocean and bay stations are monitored once a week from May to September for fecal coliform. According to the New Jersey Department of Environmental Protection (NJDEP) Surface Water Quality Standards (SWQS) NJAC 7:9 4.1, fecal coliform levels for ocean areas are not to exceed 50 per 100 milliliters of sample (SWQS 50). For the bay areas, fecal coliform concentrations are not to exceed 200 per 100 milliliters (SWQS 200). Eight sites in Atlantic County are also analyzed for enterococci bacteria in an effort to quantify other bacterial indicators of contamination. The following data is derived from the Coastal Cooperative Monitoring Program Annual Reports, published by the Division of Water Resources, NJDEP.

89. In 1989, 28 ocean and 15 bay stations were monitored as part of this program. Of the 570 ocean samples collected, 93 exceeded the SWQS 50 and 21 exceeded the primary contact criterion of 200 per 100 milliliters of sample (PCC 200). Thirty-six of the 272 bay samples exceeded the SWQS and PCC 200. Excessive, continuous rainfall contributed to bacterial loading from storm water pipes into the surf zone. Of the 466 samples collected from 26 ocean stations in 1988, 44 of the samples exceeded the SWQS 50 and 4 exceeded the PCC 200. In addition, 218 bay stations were monitored and 27 samples exceeded SWQS and PCC 200. In 1987, 587 ocean samples were collected and 83 samples exceeded SWQS 50 and 36 exceeded PCC 200. The ocean stations with geometric means exceeding the SWQS were located in Atlantic City. Thirty-seven of the 183 bay samples collected

from 10 bay stations exceeded SWQS and PCC 200.

90. As a result of this monitoring program, recreational beaches may be closed if two consecutive fecal coliform concentrations are above the PCC. From August 17 to 22, 1987, the entire Atlantic City beach was closed due to contaminated water flow from storm water pipes discharging to the ocean. Several possible sources of contamination into the storm sewer system were identified. In 1990, isolated beach closures occurred after rains. In contrast, 27 beach and 84 bay closings occurred in 1992. Twenty-two of the beach closings occurred immediately following five days of rain in August. Concentrations of fecal coliforms increase after rain due to the flushing effect of storm water runoff. Excessive fecal coliform concentrations or suspected sewage pollution accounted for 26 of the 27 ocean beach closings and all of the bay beach closings in 1992. In comparison, 10 ocean beach closings in 1991 were attributable to those causes. No closings due to floatable debris washups were required in 1991 or 1992.

91. The results of the Coastal Cooperative Monitoring Program have indicated that direct storm water discharge to the ocean and indirect discharge via tidal flow from the bay inlets can be correlated with increased concentrations of fecal coliform at the program stations. Compounding the storm water effect on backbay fecal coliform levels are bacterial loadings from illegal discharge of marine sanitation devices on boats, the pressure of large animal populations, and the resuspension of sediments by boat traffic and dredging.

92. Another indication of the water quality in an area can be derived from the State of New Jersey's annual Shellfish Growing Water Classification Charts. Waters are classified as approved, special restricted, seasonal or prohibited for the harvesting of shellfish. In general the poorest water quality areas are located in the nearshore environment of the heavily populated Atlantic City and the backbay harbors and thorofares where circulation and flow is restricted on either one or both ends. The near shore waters from Absecon Inlet to Ventnor City are condemned for the harvest of oysters, clams and mussels. The waters of Absecon Inlet are seasonal/special restricted. Seasonal areas are condemned for the harvest of shellfish except during certain times while special restricted areas are condemned for the harvest of shellfish except for further processing under special permit. The backbays extending from Absecon Inlet to Great Egg Harbor Inlet are for the most part seasonal or special restricted. A few isolated thorofares and harbors are classified as prohibited.

93. WETLAND RESOURCES. The study area encompasses both the barrier island and back bay/coastal salt marsh systems. Absecon Island, a barrier island which has been heavily developed as a residential and recreational area, is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. A large segment of the lands to the northwest of the barrier island are classified as a back bay/ coastal salt marsh system.

94. Common species of the beach and dune area on the barrier island system include beach grass (Ammophila sp.), sea-rocket (Cakile edentula), seaside goldenrod (Solidago sempervirens), poison ivy (R. radicans), groundsel-tree (Baccharis halimifolia), and marsh elder (Iva frutescens).

95. The back bays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and

a transition zone. The low marsh zone is typically dominated by saltmarsh cordgrass (Spartina alterniflora). Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms and as nursery areas for many species of fish, molluscs and other organisms. Dominant species include sea lettuce (Ulva lactuca) and eelgrass (Zostera marina). The high marsh zone which is slightly lower in elevation than the transition zone is dominated by saltmeadow cordgrass and saltgrass (Distichlis spicata). This zone is typically flooded by spring high-tides. Plants typical of the transition zone include both upland and marsh species including marsh elder (Iva frutescens), groundsel-tree (B. halimifolia), bayberry (Myrica spp.), saltgrass (D. spicata), sea-blite (Sueda maritima), glasswort (Salicornia spp.), poison ivy (R. radicans), and common reed (P. australis).

96. FISHERY RESOURCES. A study, conducted from March to December 1977 by John F. McClain and presented in "Studies of the Back Bay Systems in Atlantic County," indicates that the back bays of the Atlantic City area provide a high quality habitat for many species of fish. Fifty-nine species of fish, including bay anchovy (Anchoa mitchilli), weakfish (Cynoscion regalis), spot (Leiostomus xanthurus), windowpane (Scophthalmus aquosus), red hake (Urophycis chuss), winter flounder (Psuedopleuronectes americanus), small mouth flounder (Etropus microstomus), oyster toadfish (Opsanus tau) and Atlantic silverside (Menidia menidia), were among the species utilizing this habitat. The fish species caught in the back bays during this study are summarized in Table 9.

97. Sampling was conducted by gill, seine and trawl. The bay anchovy was present at all trawl stations and dominant in six of them while the seine samples were dominated by the Atlantic silverside at all stations except one. The fish species and their relative abundance were found to be similar to those reported in studies for Great Bay and Brigantine National Wildlife Refuge, now the Forsythe National Wildlife Refuge, (Icthyological Associates, 1974 and 1975), and the Delaware Bay (Daiber, 1974). The five most abundant species were Atlantic silverside, bay anchovy, spot, mummichog (3%) and striped killifish (1%).

98. During a 1977 ichthyoplankton study, conducted by Peter Himchak and presented in "Studies of the Back Bay Systems in Atlantic County", twenty species of larval and young finfish were found to utilize the backbays in the vicinity of Atlantic City as a nursery area. These include species endemic to estuaries as well as marine species that utilize the back bays as nursery grounds. Over 80 percent of the catch was comprised of members of the Gobiidae and Engravlidae Families. Approximately 15 percent of the total catch was comprised of naked gobies (Gobiosoma bosci), Northern pipefish (Syngnathus fuscus), weakfish (Cynoscion regalis), and bay anchovies (Anchoa mitchilli).

99. From 1972 to 1975, an intensive ecological study was conducted for the proposed Atlantic Generating Station (U.S. Fish and Wildlife Service, 1991). Trawl surveys between Holgate Peninsula and the Brigantine Inlet collected 69 species in 1972, and 76 species in 1973 and 1974. The most abundant fish taken for all years included bay anchovy (Anchoa mitchilli), red hake (Urophycis chuss), windowpane flounder (Scophthalmus aquosus), weakfish (Cynoscion regalis), spotted hake (Urophycis regia), and silver hake (Merluccius bilinearis).

Table 9.
Fish Species Caught in the Back Bays of Atlantic City
March-December 1977.

Species	Scientific Name
Haddock	Melanogrammus aeglefinus
Mummichog	Fundulus heteroclitus
American Sand Lance	Ammodytes americanus
Black sea bass	Centropristis striata
Northern pipefish	Syngnathus fuscus
White Hake	Urophycis tenuis
Spot	Leiostomus xanthurus
Striped sea robin	Prionotus evolans
Weakfish	Cynoscion regalis
Winter flounder	Psuedopleuronectes americanus
Striped killifish	Fundulus majalis
American eel	Anguilla rostrata
Northern sea robin	Prionotus carolinus
Smallmouth flounder	Etropus microstomus
Striped mullet	Mugil cephalus
Striped anchovy	Anchoa hepsetus
Atlantic menhaden	Brevoortia tyrannus
Spotted hake	Urophycis regius
Northern stingray	Dasyatis sp.
American shad	Alosa sapidissima
Banded killifish	Fundulus diaphanus
Threespine sticklebak	Gasterosteus aculeatus
Permit	Trachinotus falcatus
Crevalle jack	Caranz hippos
Fourspine stickleback	Apeltes quadracus
Orange filefish	Aluterus schoepfi
Pollock	Pollachius virens
Bay anchovy	Anchoa mitchilli
Cunner	Tautogolabrus adspersus
Northern puffer	Sphoeroides maculatus
Smooth dogfish	Mustelus canis
Striped cusk eel	Rissola marginata
Summer flounder	Paralichthys dentatus
Windowpane	Scophthalmus aquosus
Atlantic roasker	Micropogon undulatus
Red Hake	Urophycis chuss
Blueback herring	Alosa aestivalis
Lookdown	Selene vomer

Oyster toadfish	Opsanus tau
Striped burrfish	Chilomycterus schoepfi
Bluefish	Pomatomus saltatrix
Alewife	Alosa pseudoharengus
Hardtail	Caranx crysos
Hogchoker	Trinectes maculatus
White perch	Morone americana
Atlantic silverside	Menidia menidia
Sheepshead minnow	Cypinodon variegatus
White mullet	Mugil curema
Naked goby	Gobiosoma bosci

100. One hundred seventy-eight species of saltwater fishes are known to occur in waters of the nearby Peck Beach. Of these, 156 were from the nearshore waters. Of the 124 species recorded in nearby Great Egg Harbor Inlet, 28 are found in large number in offshore waters.

101. BENTHIC INVERTEBRATE RESOURCES. The diversity and composition of benthic communities are often reliable indicators of the overall quality of any particular habitat for supporting life (N.J. Bureau of Fisheries, 1979). Extensive shellfish beds, which fluctuate in quality and productivity are found in the back bays and shallow ocean waters of the study area. Surf clams (Spisula solidissima) are found offshore the barrier islands along with hard clams (Mercenaria mercenaria), blue mussel (Mytilus edulis) and blue crab (Callinectes sapidus). Since many of these animals are filter feeders and tend to bioaccumulate toxins and bacteria within their systems, bivalves are often used as indicators of water quality. Indications of this can be seen when shellfish areas are closed or have restricted harvests. In areas where this occurs, there are generally water quality or pollution problems associated with the closings.

102. Of the 83 species of benthic invertebrates identified in the vicinity of Atlantic City during a 1976 study, 15 were molluscs, 28 were crustaceans, 35 were polychaetes, and 5 were from other groups. Ampelisca abdita, an amphipod, was the dominant species and occurred at all stations. Dominant polychaetes included Streblospio benedicti, Scoloplos fragilis, and Polydora ligni.

103. The waters behind Absecon Island and in the vicinity of Absecon Inlet are seasonal or special restricted. In special restricted areas, the waters are condemned for the harvest of oysters, clams, and mussels except harvesting for further processing may be done under special permit from the New Jersey Department of Environmental Protection. Licensed clammers are allowed to relay clams to Great Bay where they cleanse themselves in its purer waters. At the northern half of the island, the waters are classified as prohibited and are condemned for the harvest of oysters, clams, and mussels from the shoreline to a distance between 0.25 miles and 2 miles. Most of Little Bay, Grassy Bay, and Reed Bay, except for isolated areas, are approved for shellfish harvest.

104. The hard clam is the most economically important shellfish of the back bays, supporting both commercial and recreational fisheries (N.J. Bureau of Fisheries, 1979). Although data on exact

locations and densities of adult hard clams within the project area is limited, they are known to be found in the intertidal and subtidal zones of bays and lower estuaries. A hard clam survey conducted in 1990 found areas with moderate (0.20 - 0.49 clams/sq. ft.) to high densities ($\geq$ 0.50 clams/sq. ft.) in the areas behind Brigantine Island (Joseph, 1990).

105. In addition to supporting some of the best hard clam resources in the State, the bays in the project area also support other species of shellfish (N.J. Bureau of Fisheries, 1979). American oysters are not usually present in commercially harvestable densities but can be found throughout the project area. Soft clams and blue mussels are primarily harvested for recreation, but occasionally commercial densities are present (Fish and Wildlife, 1991).

106. Surf Clams. The surf clam fishery supports the largest molluscan fishery in New Jersey, accounting for, by weight, 52% of the State's total molluscan commercial landings in 1993. This catch represents over 85% of the total Mid-Atlantic area catch for 1993, with a value of over 21 million dollars (N.J. Bureau of Shellfisheries, 1994).

107. A study conducted from July, 1989 to June, 1990 surveyed the standing stock of surf clams in New Jersey (Ward, 1990). This study investigated size composition, abundance, and recruitment within the New Jersey surf clam population. In 1989, the harvest zones between Barnegat Inlet and Absecon Inlet were estimated to contain over 3 million bushels of surf clams, or 40% of the state's standing stock (Fish and Wildlife, 1991).

108. According to data from New Jersey's Bureau of Shellfisheries 1993 annual surf clam inventory project, the total surf clam standing stock for New Jersey territorial waters was 12,195,000 bushels. This number represents a decrease of 775,000 bushels from 1992. Surf clam harvest records indicate that most of the harvesting activity (42%) in New Jersey occurred in the middle mile between Absecon Inlet and Barnegat Inlet. During the 1993-1994 season, over 600,000 bushels of surf clams were harvested (N.J. Bureau of Shellfisheries, 1994).

109. The area between Little Beach and Absecon Inlet from the surf to one nautical mile off-shore has been designated a conservation zone by the Surf Clam Advisory Committee. This joint committee was formed by the N.J. Bureau of Shellfisheries and representatives of the commercial surf clam industry to determine harvesting regulations. No surf clam harvesting is allowed within a conservation zone in order to promote recruitment and growth of current stock (U.S. Fish and Wildlife Service, 1991).

110. BENTHIC SURVEYS OF MACROINVERTEBRATES. The nearshore and offshore zones of the New Jersey Coast contain a wide assemblage of invertebrate species inhabiting the benthic substrate and open water. Invertebrate phyla existing along the coast are represented by Cnidaria (corals, anemones, jellyfish), Platyhelminthes (flatworms), Nemertinea (ribbon worms), Nematoda (roundworms), Bryozoa, Mollusca (chitons, clams, mussels, etc.), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), and the Urochordata (tunicates).

111. The diversity and composition of benthic communities are often reliable indicators of the overall

quality of any particular habitat for supporting life (New Jersey Bureau of Fisheries, 1979). Benthic macroinvertebrates are those dwelling in the substrate (infauna) or on the substrate (epifauna). Benthic invertebrates are an important link in the aquatic food chain, and provide a food source for most fishes. Various factors such as hydrography, sediment type, depth, temperature, irregular patterns of recruitment and biotic interactions (predation and competition) may influence species dominance in benthic communities. Benthic assemblages in New Jersey coastal waters exhibit seasonal and spatial variability. Generally, coarse sandy sediments are inhabited by filter feeders and areas of soft silt or mud are more utilized by deposit feeders.

112. Sampling associated with the proposed Atlantic Generating Station used clam dredges, trawls, and grab samples to survey the species composition, abundance, weight, and distribution of benthic macroinvertebrates in the vicinity of the Mullica River estuary, Great Bay, Little Egg Inlet, and the ocean from Brigantine Island to Long Beach Island and 5 miles seaward (Milstein and Thomas, 1976). Over 250 macroinvertebrate species were collected during these surveys. These species included: Aricidea jeffreyssi (paraonid polychaeta), Spiophanes bombyx (spionid polychaeta), Tellina agilis (tellinid bivalvia), Mediomastus ambiseta (capitellid polychaeta), Nephtys picta (nephtyid polychaeta), Unciola irrorata (aorid amphipoda), Paranaitis speciosa (phyllodocid polychaeta), Nucula proxima (nuculid bivalvia), and Ensis directus (solenid bivalvia).

113. In 1979, the NJ Bureau of Fisheries conducted a benthic study in the inlets from Great Bay to Great Egg Harbor Inlet to inventory benthic organisms and the composition of the sediments in which they lived. The resulting report discussed the relationship of the organisms to sediment composition as well as the condition of benthic communities in specific substrates. Although some species association was found with certain sediment types, no strong correlations between species diversity and density, and sediment composition were found (Fish and Wildlife Service, 1991).

114. In October 1994, a benthic-sediment assessment focusing on infauna species was conducted in the proposed offshore sand borrow sites located in Absecon Inlet and offshore of Absecon Inlet to establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow site. Other objectives were to identify the presence of any commercial and/or recreationally important benthic macroinvertebrates, and to identify the presence of ecologically important benthic communities within the proposed sand borrow sites. Five control areas were situated around the proposed sand borrow site "A" (Absecon Inlet) and three around borrow site "B" (offshore area) to offer comparisons with the data. Sample locations in relation to the proposed borrow site can be seen in Appendix A. The sediments inhabited by the benthic community were very sandy, with sand fractions ranging from 82.1 to 99.8 percent in area "A" and from 73.4 to 99.9 percent in area "B". Sediments from area "A" varied from poorly sorted to very well sorted. Proposed borrow area "B" sediments varied from moderately well sorted to very well sorted (Battelle Ocean Sciences, 1995).

115. The results of the benthic sampling from the 38 sample locations reveal that borrow area "A" is characterized by relatively low infaunal abundance (mean, 990 individuals/m^2) and low species diversity. Characteristic organisms included haustoriid amphipods, particularly Acanthohaustorius millsi and Protohaustorius sp. B. The archiannelid worm Polygordius was rare in this proposed borrow area. Area "B" was characterized by relatively high infaunal abundance (mean, 1700

individuals/m^2) and low species diversity. Characteristic organisms in this area included Polygordius and Protohaustorius sp. B. This study also discovered the presence of the Atlantic surfclam Spisula solidissima at mean densities of about 10-20 individuals/m^2.

116. Total macrofaunal abundance per station in area "A" ranged from 20 individuals/0.1 m^2 at three stations to 260 individuals/0.1 m^2 at one station. Mean total abundance within borrow area "A" was 99 ($\pm$ 36) individuals/0.1 m^2. The contribution of major taxinomic groups varied within this area. Arthropods were the predominant component of 13 stations, contributing between 67 and 94% of the individuals present at those stations. Annelid worms were the most numerous major taxon at three stations, ranging from 47-52% of the individuals present. The abundance of the selected taxa within the areas sampled can be seen in Appendix A.

117. Differences in methodology between the present study and some published studies make direct comparison of results inappropraite. However, general comparisons are useful. Total infaunal abundance found during this study may be roughly compared to that found for an offshore sandy area near Delaware Bay. The abundance recorded for this study (approximately 1400 to 1600 individuals/m^2) are higher than those reported by Maurer et al. (1979) for Hen and Chicken Shoals. They reported abundances ranging from about 100 to 700 individuals/m^2 for stations located at depths similar to those occurring in the Absecon Inlet Area. Samples studied by Maurer et al. (1979) were rinsed over a 1.0-mm mesh sieve while the Absecon samples were rinsed over a 0.5-mm sieve, thus abundances would be expected to be lower. The relative importance of haustoriid amphipods in the benthic communities in the Absecon Inlet area mirrors that found by Maurer et al. (1979). Maurer et al. (1979) also noted that species of haustoriids generally differed in their distribution relative to the shoreline. Acanthohaustorius millsi typically occurred in the nearshore area, while Parahaustorius longimerus occurred further offshore. In the Absecon Inlet areas, both species characterized relatively nearshore stations, while Protohaustorius sp B characterized offshore stations (Battelle Ocean Sciences, 1995). The complete benthic analysis can be found in Appendix A.

118. Since the time of the 1994 benthic sampling, another borrow area was added as a potential source of sand for this beachfill. This potential borrow area is located just offshore of Great Egg Harbor Inlet. In addition, another 76 acres were added to area "A" since the original benthic surveys were done. For this reason, a second round of benthic sampling was conducted for these areas in October 1995. In addition to the benthic surveys, a surf clam survey was done for all three potential borrow areas.

119. Surf Clam Surveys. During the 1995 sampling, 13 stations were sampled within the proposed borrow areas as well as the surrounding areas. The results of this benthic analysis indicate a relatively low species richness in both borrow areas with the mean number of species not exceeding 11 in either borrow area. No significant differences were found between the borrow areas, between the borrow areas and the nearshore reference areas, or between the borrow areas and the Bight Apex area which was used as a reference (Versar, 1996). The abundance of species within the borrow areas was also relatively low, less than 2,000/m^2. Again, no statistically significant differences were detected between the borrow areas or between the borrow areas and the nearshore reference area. Total abundance in the Bight Apex area was significantly greater than in the borrow areas, by a factor of

17 to 40 (Versar, 1996). The difference is mostly due to a large abundance of a bivalve and two polychaetes in the Bight Apex area. These species are Nucula annúlata (3,970/m^2), Polygordius spp. (13,006/m^2) and Prionospio steenstrupi (5,046/m^2).

120. The Versar report concluded that, except for the presence of surf clams, no significant attributes of the benthic community at the proposed borrow areas favor the selection of one borrow area over another. Also, measures of benthic community condition did not vary substantially between the proposed borrow areas and any of the reference sites in a way that would preclude the use of the areas.

121. The surf clam survey was conducted using a commercial hydraulic clam dredge equipped with a 72 inch knife to determine the abundance of clams in each borrow area. The areas were surveyed by conducting 3 five-minute tows within each proposed borrow area. The results of these tows indicate that commercially harvestable quantities of clams exist within these areas. The highest concentration was found in area "B", where between 25 and 50 bushels of clams were collected during the 5-minute tows. The average number of clams per bushel was 156. The Great Egg Harbor borrow area "C", had numbers ranging from 11 to 40 bushels per tow, with an average of 232 clams per bushel. Potential borrow area "A" produced between 15 and 23 bushels per tow with an average of 145 clams per bushel (Versar, Inc., 1995).

122. WILDLIFE RESOURCES. Marsh complexes along the New Jersey coast provide a valuable nesting habitat for the seabird population, including the common tern (Sterna hirundo). Common species occupying dredged material disposal areas, especially older sites that have been revegetated, are the least terns (Sterna albifrons), great black-backed gulls (Larus marinus), herring gulls (Larus argentatus), and the gull-billed terns (Gelocheliodon nilotica) who seek out those sites that have reverted to saltmarsh. Since the least terns are limited to a sandy substrate, unvegetated dredged material islands provide an alternative to barrier island beach habitats. Common terns occupy marsh habitats almost exclusively while the laughing gulls are found on both marsh and disposal sites. Although extensive development and disturbance of the natural conditions of the barrier islands has made this habitat the least utilized, wading birds, such as the great egrets (Casmerodius albus), black-crowned night herons (Nycticorax nycticorax), and yellow-crowned night herons (Nyctanassa violacea), are known to inhabit the barrier islands. Snowy egrets (Leucophoyx thula), glossy ibis (Plegadis Falcinellus) and little blue herons (Florida caerulea) occupy dredged material islands. The wading birds will typically arrive in mid-March and remain until mid-fall, when they travel south.

123. The New Jersey coast in the vicinity of the study area is also known as an important wintering ground for a number of waterfowl species. Species include the Atlantic brant (Branta bernicla), black duck (Anas rubripes), Canada goose (Branta canadensis), snow goose (Chen hyperborea), widgeon (Marela americana), scaup (Aytha spp.) and scoter (Melanitta spp.). Over 35 percent of the Atlantic Flyway American black duck (A. rubripes) wintering population utilizes the coastal marshes of New Jersey.

124. A 1989 survey of the Atlantic coast of New Jersey found 14 species of colonial waterbirds nesting in 39 separate colonies in the Reeds Bay/Absecon Bay area. The survey noted that

black-crowned and yellow-crowned night heron populations have declined in the last decade, while egret, ibis, and gull populations have remained stable or increased (U.S. Fish and Wildlife Service, 1991).

125. Several species of marine mammals, such as the harbor seal (Phoca vitulina), grey seal (Halichoerus grypus), ringed seal (P. hispida), harp seal (P. groenlandica), and hooded seal (Cystophora cristata), are occasionally seen in the bay areas between December and June. Bottle-nosed dolphin (Tursiops truncatus) are commonly seen in Absecon Inlet in the summer, while striped dolphin (Stenella coeruleoalba) and harbor porpoise (Phocoena phocoena) are occasionally observed in the spring. Other marine mammals that occur in the area include right whale (Balaena glacialis), pilot whale (Globicephela macrorhynchus), pygmy sperm whale (Kogia breviceps), Atlantic white-sided dolphin (Lagenorhynchus acutus), and Risso's dolphin (Grampus griseus).

126. According to studies conducted at the Forsythe National Wildlife Refuge, mammals occurring along streams and on the marsh near woodlands, in and around the study area, include the opossum (Didelphia marsupialis), shorttail shrew (Blarina brevicauda), least shrew (Cryptotis parva), starnose mole (Condylura cristata), and masked shrew (Sorex cinereus). Bat species sighted along watercourses and in wooded areas include the little brown bat (Myotis lucifugus), silver-haired bat (Lasionycteris noctivagans), Eastern pipstrel (Pipistrellus subflavus), big brown bat (Eptescius fuscus), and red bat (Lasiurus cinereus). Upland fields and woodlands support the Eastern chipmunk (Tamias striatus), Eastern cottontail (Sylvilagus floridanus), various mice and vole species, muskrat (Ondatra zibethicus), raccoon (Procyon lotor), longtail weasel (Mustela frenata) and mink (Mustela vison). In addition, gray fox (Urocyon cinereoargenteus) and river otter (Lutra canadensis) have been identified on colonial seabird islands.

127. A number of upland and fresh water species of reptiles and amphibians occur in the study area. Common reptiles include the following turtles and snakes: the snapping turtle (Chelydra serpentina), stinkpot (Sternothaerus odoratus), Eastern mud turtle (Kinosternos subrubum), Eastern box turtle (Terrapene carolina), diamond back terrapin, Eastern painted turtle (Chrysemys picta), northern watersnake (Natrix sipedon), Eastern garter snake (Thamnophis sirtalis), Northern black racer (Coluber constrictor), and Northern redbellied snake (Storeria occipitomaculata). The redbacked salamander (Plethodon cinereus), four-toed salamander (Hemidactylium scutatum), Fowler's toad (Bufo woodhousei), Northern spring peeper (Hyla crucifer), New Jersey chorus frog (Pseudarcrus triseriata), green frog (Rana utricularia), and Southern leopard frog (Rana pipiens) are all common species of amphibians found in the area.

128. ENDANGERED AND THREATENED SPECIES. Federally designated endangered and threatened species found within the study area include the endangered bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), Kemp's Ridley turtle (Lepidochelys kempii), hawksbill turtle (Eretmochelys imbricata), leatherback turtle (Dermochelys coriacea) and the threatened piping plover (Charadrius melodus), green turtle (Chelonia midas), and loggerhead turtle (Caretta caretta). Peregrines utilize coastal beaches and salt marshes within the study area extensively during migration, and to a lesser extent in summer and winter. Migrating and overwintering bald eagles utilize the study area's coastal marshes where they feed on waterfowl. However, no eagles are

known to nest in the area. The highest plover use occurs on the southern tip of Brigantine Island along Absecon Inlet, and the adjacent ocean-front beaches.

129. A number of Federal or State endangered or threatened species may occur in the vicinity of the study area. Eleven threatened or endangered bird species may occur within the study area. The State endangered species occurring in the Atlantic City area include osprey (Pandion haliaetus), least tern (Sterna albifrons), and black skimmer (Phynchops nigra). The Federally endangered peregrine falcon (Falco peregrinus), and bald eagle (Haliaeetus leucocephalus), along with the State endangered Cooper's hawk (Accipiter cooperi) are migrant species. The State threatened species include marsh hawk (Circus hudsonius) and short-eared owl (Asio flammeus) as winter residents, the pied-billed grebe (Podilymbus podiceps) and great blue heron (Ardea herodias) as both winter and summer residents, and the migrant merlin (Falco columbarius).

130. Several species of threatened or endangered sea turtles and whales occur in the coastal and nearshore waters of the study area, although all are transients. The endangered hawksbill turtle (Eretmochelys imbricata), leatherback turtle (Dermochelys coriacea), and Atlantic ridley turtle (Lepidochelys kempii), and the threatened loggerhead turtle (Caretta caretta), green turtle (Chelonia mydas) are five species of sea turtles believed to occur in the nearshore waters of the Atlantic Ocean and bay waters. Six species of endangered whales migrate through the North Atlantic and may be found off the coast of New Jersey. These are the blue whale (Balaenoptera physalus), finback whale (Balaenoptera physalus), humpback whale (Megaptera novaeangliae), right whale (Eubalaena spp.), sei whale (Balaenoptera borealis), and sperm whale (Physeter catodon).

CULTURAL RESOURCES EVALUATION

131. The prehistoric occupation of New Jersey and the Atlantic Coast region has been categorized by archaeologists into three general periods of cultural development: Paleo-Indian (15,000 years before present (B.P.) - 8,500 B.P.), Archaic (8,500 B.P. - 5,000 B.P.), and Woodland (5,000 B.P. - 400 B.P.). Few Paleo-Indian sites have been located in the coastal region of New Jersey. This is partly due to the low population density and nomadic lifestyle of the people from the period, as well as from the inundation of sites by sea level rise and burial under thick layers of alluvium and modern cultural deposits.

132. The Archaic period is marked by a rise in sea level and subsequent changes in the flora and fauna. The warmer and wetter climate resulted in the reduction of open grassland and a proliferation of oak and hemlock forests. An increasingly wide range of plant and animal resources was exploited as groups migrated seasonally to take advantage of varying environmental conditions. Nearly all drainages in New Jersey show some signs of Archaic period settlement although the late Archaic phase is better represented than the early Archaic.

133. The Woodland period can be divided into Early Woodland (3,000 B.P. - 1,000 A.D.) and Late Woodland (1,000 A.D. - 1,650 A.D.) periods. The Early Woodland period is characterized by the emergence of stable and intensive estuarine and riverine adaptations, increasing cultural diversity,

increasingly sedentary lifestyle that relied more heavily on agriculture, and the introduction of pottery. Although relatively few New Jersey sites have been reported, the sites that do exist indicate a preference for estuarine and bay locations, and an emphasis on exploitation of shellfish from tidal estuaries and major saltwater bays. The Late Woodland period is the best-represented prehistoric period in New Jersey and is characterized by an increasingly sedentary lifestyle and corresponding reliance on agriculture. New Jersey sites are primarily located along major river systems although coastal areas along the bays were also used.

134. The time during which the Native American population came into contact with the Europeans is known as the Contact Period (1,650 A.D. - 1,800 A.D.). In the study area, native Americans living in Atlantic County at this time were the Lenni-Lenape Indians, who occasionally camped on Absecon Island, which they called Absegami, an Indian word for "place of the swans".

135. In 1614, Dutch sailors landed in Atlantic County and named the area and river Eyren Haven, or Little Egg Harbor, because of the number of birds' eggs they found along the banks of the river. Later the river was renamed Mullica River to avoid confusion with the Great Egg Harbor River to the south. Prior to 1852, the location of Atlantic City was an undeveloped island 5 miles off the mainland and separated from it by a series of bays, sounds, and salt meadows. Known as Absecon Island or Absecon Beach, the frequency of shipwrecks and isolation of the island made it an attractive spot for refugees from war or the law. Dr. Jonathan Pitney of Absecon, "the father of Atlantic City", was the first to see the area's possibility as a "bathing spa". In 1853, Richard Osborne mapped the bathing village and christened the area Atlantic City. The city was incorporated in 1853. Development along the bay side of Atlantic City included the 1890 improvements of Gardner's Basin. Gardner's Basin played an important role in the development of Atlantic City and was a major center for shipbuilding, commercial fishing and pleasure boating, and has contributed to life-saving activities operating out of the Absecon Inlet. The remainder of Absecon Island quickly grew with the development of Ventnor City, Margate City and Longport Borough. These municipalities constitute one of the most intensively developed seaside resort areas in the country.

136. There are numerous historic properties listed on the National Register of Historic Places within the general project vicinity. These include the Absecon Lighthouse and several hotels, apartment buildings, churches, and the Marvin Gardens Historic District. Two properties, the Atlantic City Convention Hall and Lucy, the Margate Elephant, have been designated National Historic Landmark status.

137. Over three hundred vessels have been wrecked on the shoals off Brigantine and Absecon Islands since the late 1700's. Coastal storms, treacherous northeast winds and swift tidal currents coupled with historically heavy coastal traffic has caused the documented loss of dozens of sailing vessels, steamships, barges, tugs and large modern ships off the New Jersey Coast. A variety of potential submerged cultural resources in the project vicinity could date from the first half of the seventeenth century through the Second World War. The 1990 NOAA chart and U.S.G.S. quadrangle maps for the project area show numerous shipwreck sites on the shoals and just off the shoreline.

138. The Philadelphia District conducted two cultural resources investigations for the project in

1995. In the first study, entitled "A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey (Cox and Hunter 1995), researchers investigated two borrow areas and an eight-mile segment of tidal zone and shoreline along Absecon Island. Magnetometer, side-scan and bathymetric data analysis identified 5 potentially significant underwater resources in the Absecon Inlet Borrow Area. No targets of any kind were identified in the Offshore Borrow Area. The shoreline survey identified two historic entertainment piers that are potentially eligible for listing in the National Register of Historic Places - the Steeplechase Pier and the Garden Pier.

139. In the second study, submitted as an executive summary entitled "A Phase 1 and 2 Submerged and Shoreline Cultural Resources Investigation, Brigantine Inlet to Hereford Inlet, Atlantic and Cape May Counties, New Jersey" (Cox 1995), archaeologists conducted additional remote sensing investigations in the borrow areas at Absecon Inlet and Longport, and conducted underwater groundtruthing operations at selected high probability target locations. The remote sensing survey identified 2 additional high probability targets in the expanded Absecon Inlet Borrow Area, bringing the total to 7 high probability targets. Underwater ground truthing operations were conducted at 6 of these 7 target locations. One high probability target was not investigated during ground truthing operations. Although site conditions in the inlet limited the ability of the divers to confirm the material responsible for generating each target, a re-analysis of previously collected and newly acquired remote sensing data suggests that 4 of the 6 targets exhibit strong shipwreck characteristics. Historical research shows that one of these 4 targets, although not confirmed in the field, is the probable location of the 85 foot barge "Troy", a modern vessel that sank in the inlet in the early 1980's. Researchers recommend that five high probability targets be avoided during construction (see figure 51 in the Project Impacts section of this report.

140. No targets were found in the Longport or Offshore borrow areas during the second study.

EROSION CONTROL STRUCTURE INVENTORY

141. A site inspection of the existing coastal structures on Absecon Island was conducted in January 1994. Existing shore protection structures include timber and concrete bulkheads, concrete seawalls, stone revetments, and stone and timber beach groins. The existing condition of erosion control structures along Absecon Island are inventoried in Appendix A.

142. The bulkheads protecting Absecon Island, both along the inlet and the ocean front, are constructed of timber and concrete and conditions vary from excellent to poor. Construction of the timber bulkheads include two basic designs, which are essentially the same. Both designs require a single or double row of king piles (through a cross section) connected to a double row of timber sheet piling by means of bolted connections to a face and a lock waler. However, one design also includes an anchor pile connection.

143. The top elevation of the bulkheads vary between +10 to +15.5 MLW along the Absecon Inlet frontage, where there are two different sections of bulkhead. The new anchored bulkhead along

Maine Ave. from Caspian Ave. to Atlantic Ave. (2200 ft. in length) was constructed in 1993 and is in excellent condition. The remaining sections from Atlantic to Euclid Aves. (300 ft. in length) and those from Seaside to Metropolitan Aves. (approx. 1000 ft. in length) were constructed in 1935 and are in very poor condition. The section from Seaside to Metropolitan is buried under sand and is discontinuous in many areas.

144. In Ventnor, all timber and concrete bulkheads were constructed by private interests, and no plans for any of the concrete bulkheads exist in any state or local municipality record. There is 5300 feet or about one (1) mile of concrete bulkhead and 3400 feet of timber bulkhead in the city of Ventnor. All the concrete bulkheads were constructed between 1925 and 1935, top elevations vary between +12 to +13 MLW, top widths vary between 2 and 3 feet, and conditions range from poor to good. All the concrete bulkheads are mostly intact and continue to provide protection to beachfront properties and street ends. The timber bulkheads in Ventnor were constructed between 1950 and 1952, with approximately 500 feet being replaced following the March 1962 storm. Top elevations vary between +10 and +13 MLW. The majority are in fair condition. Short gaps in construction (less than 20 ft.) exist at the Baton Rouge, Austin, and Amherst Place street ends.

145. In Margate, the entire shorefront (8450 feet or 1.6 miles) is protected by timber bulkheads, which were built between 1957 and 1964. The newest sections of bulkhead at Granville and Rumson Avenues were replaced in 1993. Top elevations vary between +10 and +13 MLW, and the majority are in fair to good condition.

146. In Longport, the entire ocean front (1.4 miles) is protected by 4050 feet of timber bulkhead and 3300 feet of concrete seawall. There is also 55 feet of steel sheet pile bulkhead at the seaward end of 28th Ave. This bulkhead is in poor condition with significant corrosion, however, it still functions as designed. The concrete seawall is a combination curved face and stepped structure, which was originally built in 1917 and was rehabilitated in 1981, at which time the curved face was repaired and the top elevation was raised to +11.6 MLW (see photo #11 in the Engineering Appendix). When the seawall was originally constructed, the design did not include a pile support for the rear of the structure, which has resulted in the potential for a lack of stability of the wall if the fill supporting the rear of the structure should erode. A stone revetment with 18 inches of concrete void filler provides toe protection along the length of the seawall. The seawall is in fair to good condition, with some minor cracking and spalling. The structure has remained stable since 1963 and has been effective in providing protection to the properties behind it.

147. The timber bulkheads in Longport vary in top elevation from +10 to +14 MLW and the majority are in fair to good condition. The most recent section replaced was at 30th Ave. and the property just north of 30th, in 1984. Those sections at Pelham, Manor, and 31st Aves. are planned to be replaced in the near future by the State and municipality.

148. GROINS. There are currently eight (8) groins, approximately 500 feet apart, in Atlantic City along the Absecon Inlet frontage. Two timber groins were constructed by the City and State in 1930-32, and repaired and protected with stone ends in 1958. Five stone spur groins and one timber and stone groin were also constructed along the inlet by the City and State between 1946 and 1958. Also

along the inlet in Atlantic City is the Oriental Avenue jetty. It was built by the Federal Government in 1946-48 and extended in 1961-62 to its present length, and was rehabilitated by the State in 1983. All eight inlet groins and the jetty are in good condition.

149. Along the ocean coast of Absecon Island, there are a total of twenty-nine (29) beach groins. Nine are stone groins that are in good to fair condition with little or negligible displacement or loss of stone along their visible length. Several of the stone groins in Atlantic City were rehabilitated by the City and the State in 1983. The work included extending and raising the crest elevation of the Vermont Ave. groin, raising the crest elevation and filling voids in the armor with concrete at the Massachusetts Ave. groin, and construction of a new timber groin with stone extension directly adjacent to the existing structure at Illinois Ave. Eleven beach groins are constructed of timber that are in fair to poor condition, many with rotting timbers which render them permeable. It appears that the local communities are maintaining the stone groins in a more intact state than the timber groins. There are nine groins constructed of stone and timber cribbing that are in poor condition, with all but a few cases existing in a state of debris, nearly invisible. These do not appear to serve their original function, and similar structures have not been constructed since the late 1920's.

150. REVETMENTS. There are three stone revetments providing erosion protection for bulkheads and seawalls on Absecon Island. There is a new stone revetment along the length of the new timber bulkhead at Maine Avenue on the Absecon Inlet frontage. It is constructed of 2 to 3 ton stone and the slope of the revetment follows the existing slope of the sand fronting the bulkhead. There is also a stone revetment providing erosion protection along the length of the combination curved face and stepped reinforced concrete seawall which extends from 11th Ave. to 15th Ave. and then from between 23rd and 24th Aves. in the city of Longport. Top elevation of the revetment varies between +6 to +6.3 MLW and has concrete void filler in the upper 18" of stone. It is in fair to good condition.

151. Also in the city of Longport is a new stone revetment at 11th Ave., extending to the inner end of the stone groin constructed at Atlantic Ave. The crest of the revetment was constructed with a top width of 14 feet, a top elevation of +8.0 MLW, using 8 to 9 ton weight rough quarrystone. The revetment fronts an existing timber bulkhead with a top elevation varying between +10.0 and +12.0 MLW, and replaces a previous concrete block and stone revetment. The revetment was constructed by the State of New Jersey in 1993.

152. OUTFALLS. At the time of the previous structure inventory, most outfalls were intact and in fair to good condition. At the present time, the condition of some of these outfalls has degraded. In Atlantic City, all outfalls are intact up to approximately the mean low water line; however, several of the existing outfall pipes have broken off at pipe sections located in the surf zone. The existing length of these outfalls is not adequate to assure unhindered drainage for those proposed beachfill alternatives having a berm width of 200 feet or greater. Therefore, plans to extend the outfalls were developed during plan formulation. This required extending approximately 270' of 20" diameter ductile iron pipe, and 170' of 24" diameter D.I.P., with timber support systems spaced at 18 feet. 220' of 30" diameter D.I.P., and 150' of 36" diameter D.I.P. would also be extended with timber support systems spaced at 9 feet. Several outfalls in Ventnor, Margate and Longport have also suffered damage, and in some cases have sheared off completely at the bulkhead. These outfalls would also

require extention during plan folrmulation. It was assumed that outfalls in Ventnor, Margate and Longport would be replaced with 12" diameter D.I.P., for a total length of 1,650 feet, including timber support systems spaced every 18 feet.

153. BOARDWALKS. The boardwalk in Atlantic City extends from Caspian Ave. on the Absecon Inlet side around to the borough line at Jackson Ave. on the ocean frontage. The design and width of the boardwalk varies from 60 ft. wide with steel reinforced concrete girders and concrete piles (9,000 ft. in length) to a 40 ft. wide section which is a combination of timber and concrete girders and piles (6,600 ft. in length) to a 20 ft. wide section composed entirely of timber (6,700 ft. in length). The last reconstruction of the boardwalk occurred in 1993, and several major utilities including electric, storm drains and water lines are buried or strung directly underneath the decking along the boardwalk. Top of deck elevations vary from +11 to +13 MLW. The boardwalk is in fair to good condition, along the ocean frontage, with the exception of the seawardmost concrete girders from the Garden Pier to the Oriental Avenue Jetty, a distance of approximately 2,500 ft. The boardwalk along the Absecon Inlet frontage, from Atlantic Avenue to Oriental Avenue, has been repaired on frequent occasion, due to damage sustained from storm generated waves.

154. The boardwalk in Ventnor is of timber construction and is 20 ft. wide. It extends from the Atlantic City line at Jackson Ave. to Margate at Fredericksburg Ave., with a top of deck elevation varying between +12 and +13 MLW. The length is 8,750 ft and is in good condition.

155. GEOTUBES. A system of geotube reinforced dunes were constructed in Atlantic City during the summer of 1995. Geotubes have been placed in sections extending between Chelsea Avenue to Martin Luther King Boulevard and from Massachusetts to Vermont Avenues, with a total approximate length of 6,300 feet. The geotubes are supported by a base of sand, and were made of a permeable gortex material filled with a sand/water slurry. The slurry was obtained directly from the existing beach in Atlantic City at the surf zone, and at the final phase of construction, all water drained out through the geotextile skin leaving a solid tube filled with sand. The seaward edge of the geotubes is located approximately 75 ft. in front of the boardwalk. As positioned, the geotubes are 6 ft. high by 12 ft. wide, and are covered by approximately 1 ft. of sand to form a dune with a top elevation of +14.0 NGVD.

156. The geotubes were placed in areas considered to be critical to the protection of Atlantic City. During the construction of the geotube reinforced dunes, additional sand loss occurred along the already eroding beachface. Atlantic City may have exacerbated the depleted sand supply immediately seaward of the geotubes by using the beach as the borrow area.

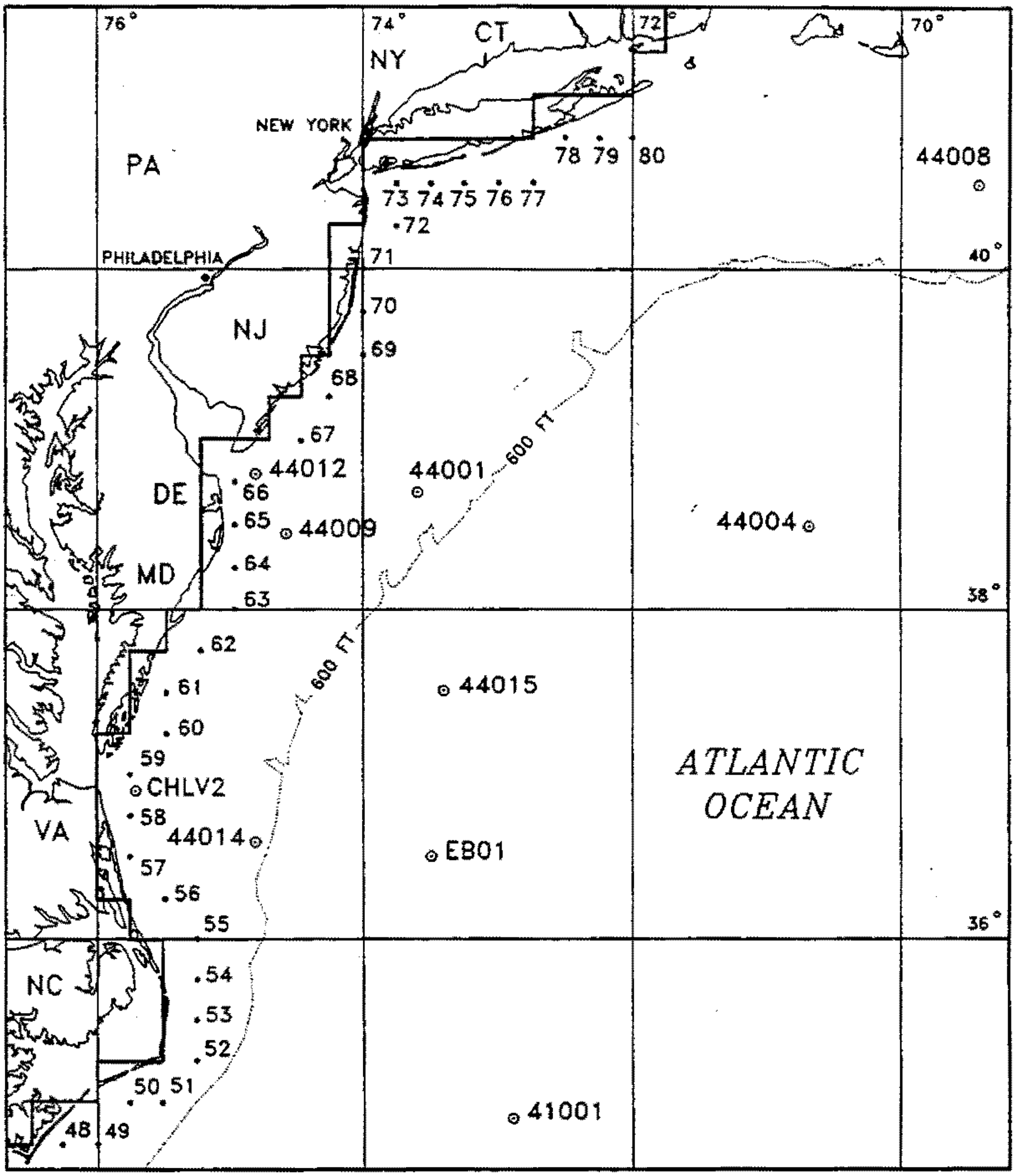
PHYSICAL PROCESSES OF THE COAST

157. A number of coastal hydraulic processes which affect the Absecon Island study area were investigated. The following paragraphs summarize these critical elements which include historic and existing wind, wave, water level and sediment conditions for the study site. A detailed discussion of historic and existing shoreline conditions, including a summary of coastal structures, is also provided.

158. WAVES. An analysis of general wave statistics for the study area is presented in a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, et al., 1993. The revised WIS data is also available digitally through the Coastal Engineering Data Retrieval System (CEDRS) developed by the U.S. Army Engineer Coastal Engineering Research Center (CERC). The wave information for each location is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992). The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate at Absecon Island. The wave statistics pertinent to the Absecon Island study are those derived for Station 68 of WIS Report 30 (Figure 5). The location of Station 68 is Latitude 39.25 N, Longitude 74.25 W, in a water depth of approximately 60 ft. Monthly mean wave heights at Station 68 for the entire 20-yr hindcast range from 2.4 ft in August to 4.4 ft in December. The maximum wave height (H_{mo}) at Station 68 for the 20-yr period is reported as 22.6 ft, with an associated peak period of 14 sec and a peak direction of 86 deg on 7 March 1962. The maximum wind speed for Station 68 for the 20-yr hindcast is reported as 89 ft/sec at 20 deg on 7 March 1962.

159. Field measurements of waves at two locations have been collected by Offshore and Coastal Technologies-East, (OCTI) for the Philadelphia District during the period November 1993 to January 1995 (Figure 6). Typical plots of wave data collected are provided in Appendix A. The data collected provide bulk parameters and directional spectral information at an offshore site (approximately 35 ft depth, 8000 ft offshore) and at a nearshore site (approximately 800 ft south of Absecon Inlet in about 20 ft of water). The offshore wave measurement site is considered representative of incident wave conditions along the project area. The nearshore wave site at Absecon Inlet reasonably monitors the transformed waves reaching the Absecon Inlet/Atlantic City shoreline after passing over the ebb delta and main navigation channel. The two gages provide data needed to validate a nearshore wave transformation model used in this feasibility study. Field data have been analyzed using directional spectral analysis techniques to produce spectrally-based bulk parameters describing the wave records as well as discretized energy densities for frequency/direction bins. Time series of zero-moment wave height, peak period and mean direction are necessary from each gage to assess the performance of the nearshore wave transformation model.

160. Wave information for use in storm erosion and shoreline change modeling was derived from two sources. First, offshore storm wave data was taken from the recent wave hindcast conducted by OCTI for the Philadelphia District. Historic storm data were generated in the hindcast using a series of numerical models applied to two storm populations. The hindcast used 15 historic hurricanes and 15 historic northeasters that have affected district coastal areas in order to formulate the storm criteria. Normal condition wave information was taken from a recent Philadelphia District hindcast of 6 years of continuous waves (1987-1993) and the 20-year WIS study. The Philadelphia District hindcast provides approximately three months of overlap with the wave gaging effort. Both data sets, generated by a directional spectral wave model, are directly compatible with the nearshore wave transformation model and provide input to shoreline change sediment transport models.

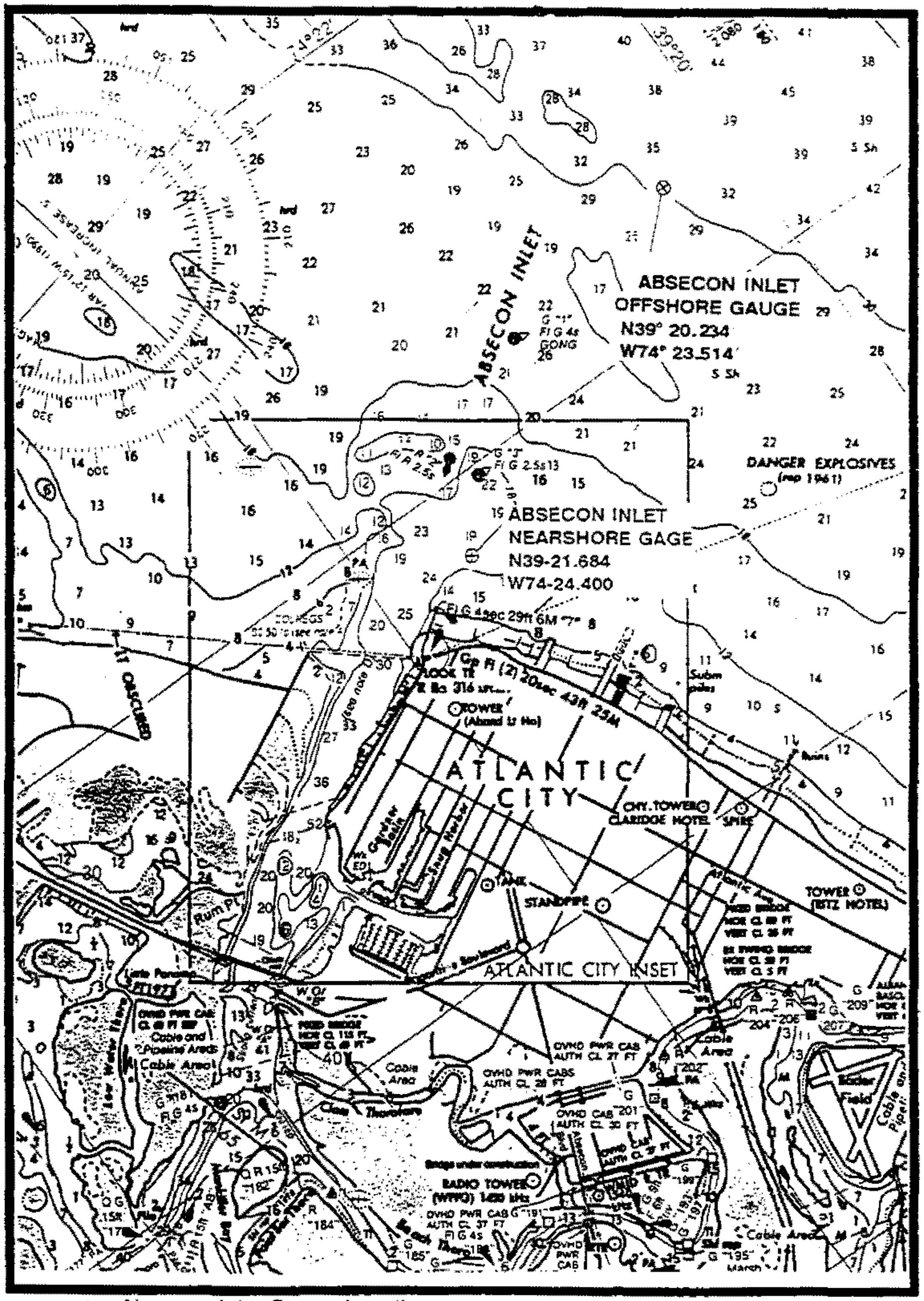


U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

ABSECON ISLAND
FEASIBILITY STUDY

Wave Information Study
Station Map

Figure 5



Absecon Inlet Gauge Locations

Figure 6

161. Extreme wave statistics are available from the OCTI wave hindcast study are provided in Table 10. These offshore waves were reported by the model at 39 degrees 20 minutes North and 74 degrees 25 minutes West and are representative of waves at the 10 meter NGVD contour.

Table 10
Extreme Wave Estimates

Return Period (yr)	H_s (ft)	T_p (sec)	Mean Direction * (deg)
2	9.94	9.9	67
5	11.31	10.6	73
10	14.07	12.1	85
20	16.27	13.2	94
50	18.96	14.7	106
100	20.93	15.7	114
200	22.87	16.7	123
500	25.39	18.0	133

* Directions are from which they are coming, clockwise from north

162. WIND AND CLIMATE. The site closest to the study area for which long-term systematic wind and climatic data are available is Atlantic City. Weather data were recorded at the Absecon Lighthouse from about 1902 to 1958. In 1943, systematic weather observations were initiated at the U. S. Naval Air Station located about 10 miles northwest of the Absecon Light. Records have been made continuously at the Air Station site (presently, National Aviation Facilities Experimental Center, Pomona) to the present. In 1958, the weather observation site in Atlantic City proper was relocated from Absecon Light about 1.1 miles northwest to the Atlantic City State Marina. The station was then moved several hundred yards to the Atlantic City Coast Guard Facility.

163. The following paragraphs are quoted from the 1992 Annual Summary of Local Climatological Data, and are considered to be fully representative of conditions along Absecon Island.

> "Atlantic City is located on Absecon Island on the southeast coast of New Jersey. Surrounding terrain, composed of tidal marshes and beach sand, is flat and lies slightly above sea level. The climate is principally continental in character. However, the

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moderating influence of the Atlantic Ocean is apparent throughout the year, being more marked in the city than at the airport. As a result, summers are relatively cooler and winters milder than elsewhere at the same latitude."

"Land and sea breezes, local circulations resulting from the differential heating and cooling of the land and sea, often prevail. These winds occur when moderate or intense storms are not present in the area, thus enabling the local circulation to overcome the general wind pattern. During the warm season sea breezes in the late morning and afternoon hours prevent excessive heating. Frequently, the temperature at Atlantic City during the afternoon hours in the summer averages several degrees lower than at the airport and the airport averages several degrees lower than the localities farther inland. On occasions, sea breezes have lowered the temperature as much as 15 to 20 degrees within a half hour. However, the major effect of the sea breeze at the airport is preventing the temperature from rising above the 80's. Because the change in ocean temperature lags behind the air temperature from season to season, the weather tends to remain comparatively mild late into the fall, but on the other hand, warming is retarded in the spring. Normal ocean temperatures range from an average near 37 degrees in January to near 72 degrees in August."

"Precipitation is moderate and well distributed throughout the year, with June the driest month and August the wettest. Tropical storms or hurricanes occasionally bring excessive rainfall to the area. The bulk of winter precipitation results from storms which move northeastward along, or in close proximity to, the east coast of the United States. Snowfall is considerably less than elsewhere at the same latitude and does not remain long on the ground. Precipitation, often beginning as snow, will frequently become mixed with or change to rain while continuing as snow over more interior sections. In addition, ice storms and resultant glaze are relatively infrequent."

164. As referenced in the 1984 Annual Summary from the State Marina site, the prevailing winds are from the south and of moderate velocity (14 to 28 miles per hour), and winds from the northeast have the greatest average velocity (between 19 and 20 miles per hour). The wind data from this period also show that winds in excess of 28 miles per hour occur from the northeast more than twice as frequently as from any other direction.

165. The maximum five-minute average velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 82 miles per hour from the north. This storm also caused the largest recorded storm surge along the Atlantic coast of New Jersey. The fastest mile windspeed recorded at the Atlantic City Marina site over the 1960 to 1984 period was recorded during Hurricane Doria in August 1971. The fastest mile wind speed was 63 miles per hour from the southeast. The wind records generally reflect the fact that the most extreme, but infrequent, winds accompany hurricanes during the August to October period. Less extreme but more frequent high winds occur during the November to March period accompanying northeasters.

166. TIDES. The tides affecting the study area are classified as semi-diurnal with two nearly

equal high tides and two nearly equal low tides per day. The average tidal period is actually 12 hours and 25 minutes, such that two full tidal periods require 24 hours and 50 minutes. Thus, tide height extremes (highs and lows) appear to occur almost one hour (average is 50 minutes) later each day. The mean tide range for the Atlantic Ocean shoreline is reported as 4.1 feet in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 5.0 feet. Absecon Channel and the back bay areas adjacent to the study area show only a small attenuation of the tide range relative to the ocean shoreline.

167. The NOAA tide gage nearest to the study area shoreline is located at the Trump Taj Mahal oceanfront pier in Atlantic City. Historically, a gage has been located on Absecon Island since July 1911. In July 1985, the gage was moved from its location at Atlantic City Steel Pier two miles south to a municipal fishing pier in Ventnor. In January 1992, the gage was moved from Ventnor to its present location at the Trump Taj Mahal Pier.

168. Water level measurements were also collected by OCTI at the offshore and inlet wave and current measurement stations at three hour sample periods. Typical plots of tidal data are provided in Appendix A.

169. CURRENTS. The Philadelphia District collected tidal current data offshore just south of the Absecon Inlet mouth from November 1993 to January 1995, with some gaps in the data due to redeployment of the instruments for a related project and weather conditions. This data includes a large set of current speed and direction measurements at a single location from a bottom mounted self-recording current meter. This data is more relevant to ocean facing shoreline parallel tidal currents than inlet currents because of the location of the current meters. The data was taken at three hour intervals. Typical plots of tidal current data are provided in Appendix A.

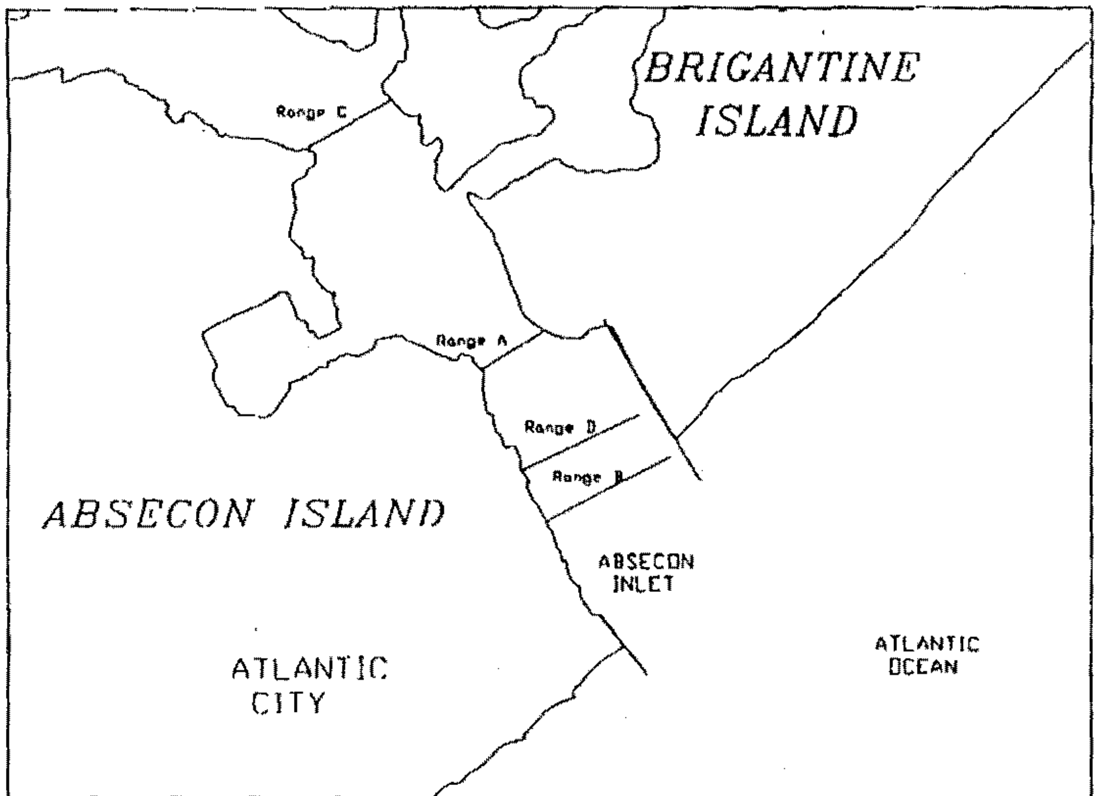
170. In addition, tidal currents and flow estimates for Absecon and Brigantine Inlets are available from a study conducted in September 1994 by CERC for the Philadelphia District. Acoustic Doppler Current Profiler (ADCP) measurements were taken at Absecon Inlet to provide estimates of depth averaged currents at specified cross-sections and flow volumes as a function of time over most of a tidal cycle. Typical plots of the current data collected are provided in Appendix A. Complete analysis results are provided in a comprehensive report entitled "Current Survey of Absecon Inlet, NJ with a Broadband Acoustic Doppler Current Profiler" available at the Philadelphia District.

171. The goal of the ADCP study was to measure the currents and discharge rates in the inlet at least every hour over a complete tidal cycle. These data were collected along four range lines (Figure 7). Range A, corresponding to channel Station 102+00, was established across the narrowest part of the inlet throat in order to capture the discharge going through the inlet. The three other ranges were established to look at current distribution across the channel. Range B starts near the Flagship Condominium near Station 76+00. Range C was established parallel to the Brigantine Bridge near Station 142+00 and Range D was established between Ranges A and B at Station 84+00.

172. There are a variety of ways to view the data collected along each of these ranges. Typical plots are provided in Appendix A. The plots show ship tracks with velocity vectors, contour plots of the velocity structure as if a slice was taken across the channel, and depth-averaged velocity plots. Time series of depth-averaged velocity and discharge estimates at each range for each transect were also developed from the data collected in this study.

173. A summary of the data collected across the inlet throat (Range A) is provided. The data indicate that during flood tide the higher water velocities are located on the south side of the channel. During ebb tide, the currents are generally uniform across the channel. During peak ebb, slightly higher velocities are concentrated on the north side of the inlet. At maximum flood, depth-averaged water velocities of over 5.6 ft/sec were measured. In general, ebb velocities were lower than the flood velocities. Typically, maximum water velocities on the ebb tide were on the order of 4.9 ft/sec. Complete analysis results for all ranges are provided in a comprehensive report entitled "Current Survey of Absecon Inlet, NJ with a Broadband Acoustic Doppler Current Profiler" available at the Philadelphia District.

174. Maximum tidal current velocities through Absecon Inlet have been previously documented as 3.1 ft/sec (U.S. Army Corps of Engineers 1943) with currents flowing past the adjacent beaches reaching maximum velocities of less than 1.0 ft/sec.



Range lines at Absecon Inlet

Figure 7

175. STORMS. Storms of two basic types present a significant threat to New Jersey's coastal zone. Hurricanes are the most severe storms affecting the Atlantic Coast. Extratropical storms from easterly quadrants, particularly the northeast, also cause extensive damage to beaches and structures along the coast.

176. Tropical storms and hurricanes, spawned over the warm low latitude waters of the Atlantic Ocean, are probably the best known and most feared storms. Hurricanes, characterized by winds of seventy-five miles per hour or greater and heavy rain, plague the Gulf and Atlantic seaboards in the late summer and autumn. Historically, the Hurricane of 1944 and Hurricane Gloria are ranked first and fifth, respectively, in terms of maximum stage at the Atlantic City gage.

177. Extratropical storms, often called "northeasters", present a particular problem to the Atlantic seaboard. Such storms may develop as strong, low pressure areas over land and move slowly offshore. The winds, though not of hurricane force, blow onshore from a northeasterly or easterly direction for sustained periods of time and over very long fetches. The damage by these storms may ultimately exceed the destruction from a hurricane. The March 1962 Northeaster ranks second only to the 1944 hurricane in terms of maximum stage. The northeasters which occurred in November 1950 and December 1992 rank third and fourth in the stage frequency analysis for the Atlantic City gage.

178. The intensity and thus the damage-producing potential of coastal storms are related to certain meteorological factors such as winds, storm track, and amount and duration of precipitation. However, the major causes of coastal damage tend to be related to storm surge, storm duration, and wave action. Storm surge and wave setup will be discussed in the storm erosion and inundation analysis included in a later section.

179. SEA LEVEL RISE. Many coastal engineers feel that sea level rise is a contributing factor to long term coastal erosion and increased potential for coastal inundation. Because of the enormous variability and uncertainty of the climatic factors that effect sea level rise, predicting future trends with any certainty is difficult. There exists many varying scenarios of future sea level rise. Corps of Engineers guidance EC-1105-2-186 states that it will be at least twenty-five years before sufficient data is collected to estimate with reasonable confidence the appropriate rate of increase or even to reach some consensus on which of the various scenarios is most likely. Until substantial evidence indicates otherwise, Corps policy specifies considering only the local regional history of sea level changes to forecast a change in sea level for a specific project area. Based on historical tide gage records between 1912 and 1986 at Atlantic City and Ventnor, New Jersey, sea level has been rising at an approximate average rate of 0.013 feet per year (Hicks and Hickman 1988). The ocean stage frequency analysis will incorporate the effects of sea level rise in the historical record. Over the proposed fifty year project life, it is assumed that sea level will rise by 0.65 feet.

180. OCEAN STAGE FREQUENCY. The stage-frequency relationship derived for this study based upon a Gumbel best-fit distribution for recurrence levels greater than a 10-yr event and based upon the Weibull best-fit distribution to annual maxima measured at Atlantic City for a 10-

yr event and lower is shown in Figure 8. Values of stage at selected reference frequencies are shown in Table 11. This relationship places the maximum water level ever recorded at Atlantic City, i.e. on September 14, 1944, of 8.21 ft NGVD at the 50-yr level and the December 1992 storm peak water level of 7.42 ft NGVD at approximately a 25-yr event. Table 12 presents the 20 highest observed stages adjusted for sea level rise. The data set of ranked maximum stages measured from the Atlantic City gage is provided in Appendix A .

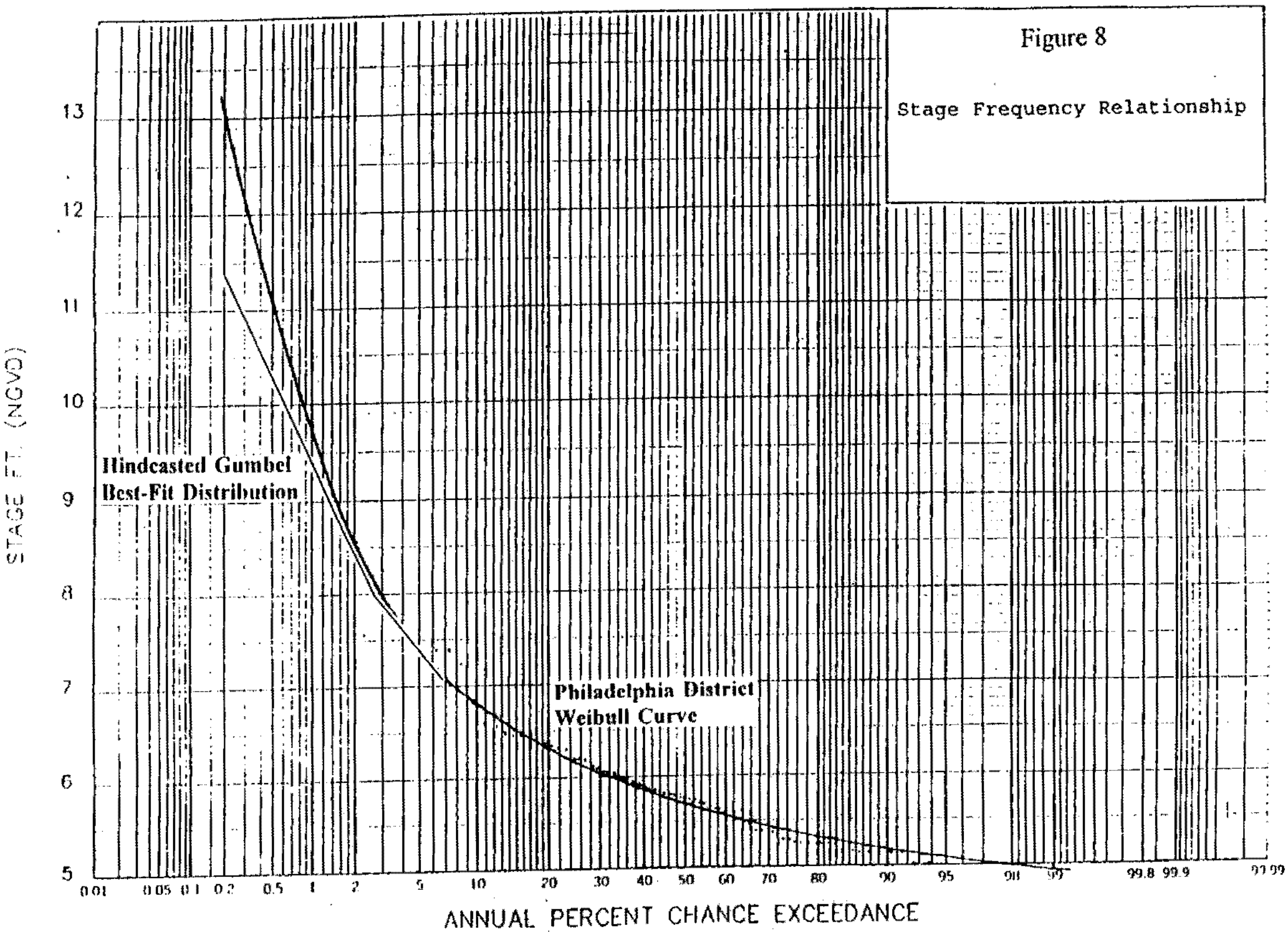


Figure 8
Stage Frequency Relationship
Hindcasted Gumbel
Best-Fit Distribution
Philadelphia District
Weibull Curve
STAGE FT. (NGVD)
13
12
11
10
9
8
7
6
5
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
ANNUAL PERCENT CHANCE EXCEEDANCE

Table 11

Ocean Stage Frequency Data

Year Event	Annual Probability of Exceedence	Water Surface Elevation (ft, NGVD)
5	0.20	6.3
10	0.10	6.8
20	0.05	7.2
50	0.02	8.2
100	0.01	9.2
200	0.005	10.1
500	0.002	11.3

Table 12
Stage Frequency Analysis
20 Highest Stages Adjusted for Sea Level Rise
Atlantic City, NJ 1912-1994

Year	Date	Rank	Adj. Stage, NGVD	Storm Type
1944	14 Sep 1944	1	8.21	HUR
1962	7 Mar 1962	2	7.58	NE
1950	25 Nov 1950	3	7.53	NE
1992	11 Dec 1992	4	7.42	NE
1985	27 Sep 1985	5	7.39	HUR
1976	9 Aug 1976	6	7.39	HUR
1991	31 Oct 1991	7	7.23	NE
1984	29 Mar 1984	8	6.83	NE
1980	25 Oct 1980	9	6.71	NE
1953	23 Oct 1953	10	6.59	NE
1989	19 Oct 1989	11	6.50	NE
1977	14 Oct 1977	12	6.47	HUR
1947	1 Nov 1947	13	6.47	NE
1972	22 Dec 1972	14	6.45	NE
1960	12 Sep 1960	15	6.40	HUR
1961	22 Oct 1961	16	6.39	HUR
1932	10 Nov 1932	17	6.36	HUR
1935	6 Sep 1935	18	6.33	HUR
1920	5 Feb 1920	19	6.32	NE
1994	Mar 1994	20	6.30	NE

181. LONGSHORE TRANSPORT. Longshore or littoral transport can both supply and remove sand from coastal compartments. In order to determine the balance of sediment losses and gains in a system, net, rather than gross, transport rates are required. Net longshore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction.

182. The net longshore transport in the vicinity of Absecon Island is from northeast to southwest, although there is a local reversal of drift on the Atlantic City shoreline near the inlet. Observations of beach offsets at the groins taken from aerial photography and onsite observations, showed a diverging nodal zone consistently located between Garden Pier and the former Steel Pier (Sorensen, Weggel, and Douglass 1989). Table13 provides sediment transport rates which have been reported for the Absecon Island study area. The sediment budget developed for Brigantine and Absecon Islands further examines longshore transport rates in the study area.

Table13
Historic Sediment Transport Rates for Absecon Island and Vicinity

Location	Source	Gross Transport (cu yd/yr)		Net Transport (cu yd/yr)
		North	South	
Brigantine Island	CENAP House Doc #94-631 Group III	250,000	350,000	100,000 S
Absecon Inlet	CENAP Group I, II, III	500,000	600,000	100,000 S
Atlantic City	Caldwell MFR (4/18/58)	450,000	550,000	100,000 S
	Caldwell 1966 CERCR 1-67	500,000	600,000	100,000 S
Absecon Island	Wicker 1967 letter to Caldwell	107,000	199,000	92,000 S
	Caldwell 1968 letter to Wicker	250,000	400,000	150,000 S

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SEDIMENT BUDGET

183. A sediment budget study is used to determine the sources, sinks and volumetric rates of material transported into and out of a particular coastal compartment over a specified time period. This study is accomplished by thoroughly investigating the various factors that influence sediment erosion, transportation, and deposition in a study area. Due to the difficulty in measuring some of these factors, reliability of a sediment budget varies depending on the characteristics of each site and quality of input data. When a sediment budget is conducted to understand the long-term change of a shoreline, a sufficient time interval must be used to average out seasonal variations.

184. Both natural trends and man-made factors (such as beach fill and coastal structures) are important parameters in a sediment budget analysis. Various factors considered as sources or credits of material include dune, cliff, and backshore erosion, beach fill, riverine sediments, eolian transport, and onshore and longshore transport. Factors considered as sinks or debits include dune and backshore storage, inlets, lagoons, overwash, dredging activities, beach mining, submarine canyons, eolian transport, and offshore and longshore transport out of the study area. A particular coastal compartment may require that many or only a few of these elements be considered in the analysis. Sediment budget assumptions and analysis techniques are discussed in a number of references including the Shore Protection Manual (1984), EM 1110-2-1502 (1992), and Meisburger (1993).

185. SEDIMENT BUDGET DATA FOR ABSECON ISLAND. A sediment budget has been developed for the length of shoreline from Brigantine Inlet to Great Egg Harbor Inlet. Several pertinent source and sink factors for the study area are discussed below.

186. Navigation Features. The authorized project at Absecon Inlet provides for an entrance channel 20 ft deep (MLW) and 400 ft wide in the Atlantic Ocean and through the inlet, and for an entrance channel 15 feet deep into Clam Creek, with a turning basin of like depth within Clam Creek (Figure 9). The existing project was completed in 1957.

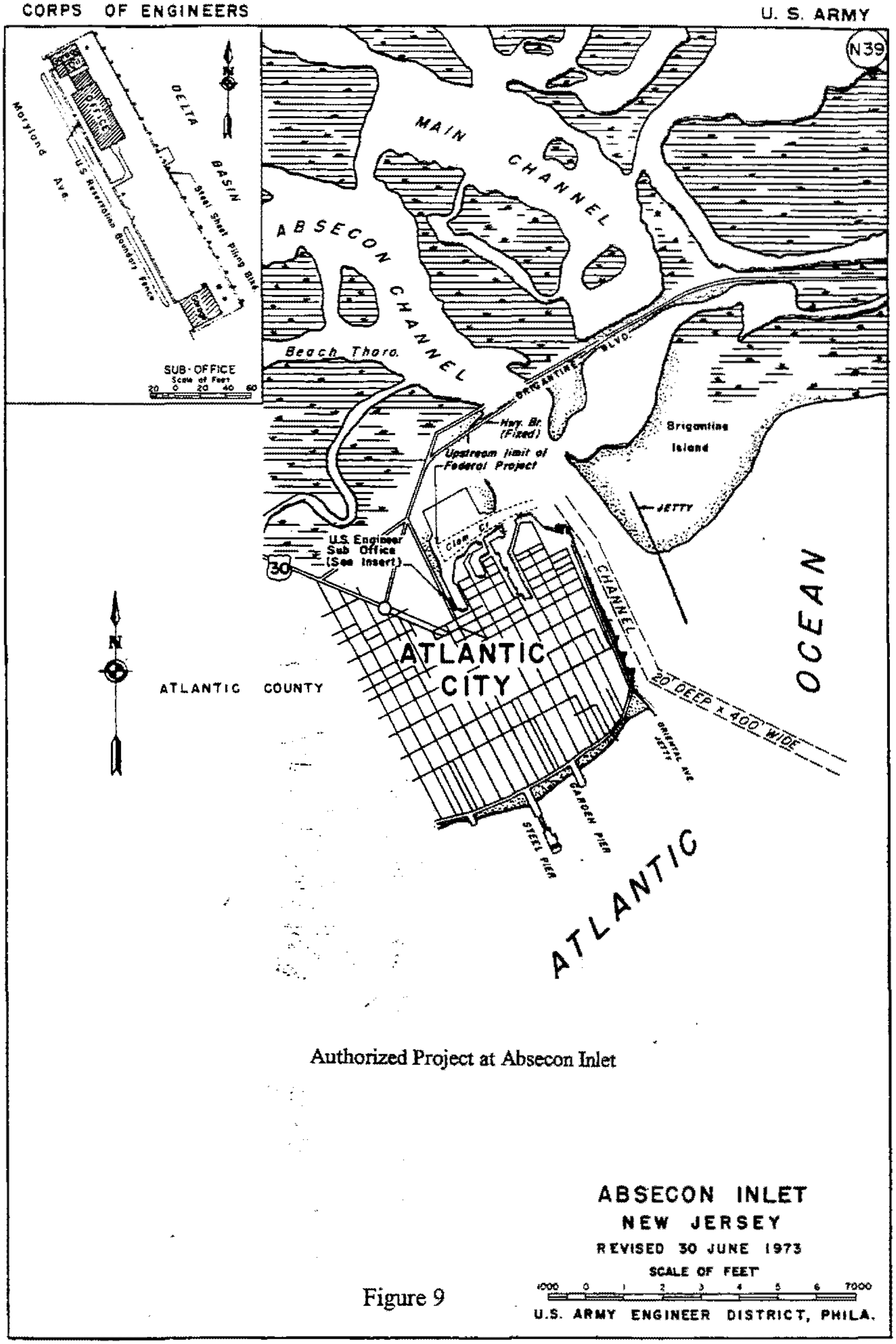
187. Structures in the vicinity of Absecon Inlet include the Brigantine jetty to the north of the inlet, the Oriental Avenue groin to the south, and 7 stone groins and a timber bulkhead along the inlet-facing shoreline of Atlantic City (see Figure 21 later in this report). These structures are not part of the authorized Federal navigation project for Absecon Inlet, but are important to processes affecting the inlet.

188. Subsequent construction of the Oriental Avenue groin, the Atlantic City inlet shoreline groins, and the Brigantine jetty have successively reduced channel and shoreline fluctuations. Southerly longshore transport has caused accretion of the Brigantine shoreline in the vicinity of the Brigantine jetty and reduction of material being bypassed to Atlantic City. Additionally, hopper dredging and offshore disposal through 1978 and the 1986 beach fill/borrow operation have decreased the volume of material in the ebb-tidal delta.

189. ABSECON INLET SHOAL VOLUME CHANGES. Bathymetry with coverage beyond the

immediate area of inlet dredging, adequate to calculate changes in shoal volumes over time, includes a 1941 Corps survey, NOAA chart bathymetry from approximately 1972, and a 1994 Corps survey. The latter survey is very limited in area to the north and south of the navigation channel, limiting the area of shoal volume change calculation.

190. The volume stored by the Brigantine Jetty, built in the mid-1950s, is estimated to be approximately 1.5 million cubic yards. This includes both the fillet north of the jetty and shoals adjacent to the jetty along the northern shore of the inlet.



Authorized Project at Absecon Inlet

Figure 9

191. Inlet ebb tide shoal volume changes were calculated over an 8000 by 5000 foot area which had overlapping coverage in the three available surveys. The results show a 1.1 million cubic yard loss in the shoals from 1941 to 1972, and no appreciable shoal volume change over the limited area of common data from 1972 to 1994. Bathymetry of the inlet from 1941, 1977 and 1994 are shown in Figures 10 to 12.

192. Dredging History. Table 14 and Figure 13 provide a history of maintenance dredging in Absecon Inlet since 1915. Maintenance dredging in the inlet channel was last performed by hopper dredge in July 1978. Since 1978, controlling depths have been in the range of 17 to 19 ft MLW. These depths result from a combination of natural processes and beachfill/borrow activities. Between 1978 and 1986, the navigation channel remained sufficiently deep through natural tidal scour. However, in 1986, approximately 1,000,000 cubic yards of material was removed from the shallow areas north of the inlet navigation channel as a borrow source for an Atlantic City beachfill operation.

193. Previous analyses of dredging records indicate a range of shoaling rates dependent upon the time period analyzed. As part of the Absecon Inlet physical model study, the U.S. Army Engineer Waterways Experiment Station (1943) conducted a 10-year dredging base test of existing prototype conditions with a 400-ft wide and 20-ft deep channel. Subsequent to the initial channel cut, an average of 109,000 cu yd of material per year was dredged from the model channel to maintain project dimensions. An approximate analysis of average annual "pay place" quantities from 1970 to 1978 resulted in a maintenance dredging rate of 81,800 cu yd/year. No maintenance dredging has been required from 1978 to 1994 indicating a shoaling rate of zero cu yd/year. The inlet processes analysis conducted for this feasibility study investigated Absecon Inlet bathymetry and volumetric changes. A discussion of historic, present day, and future inlet processes are presented in a later section of this report.

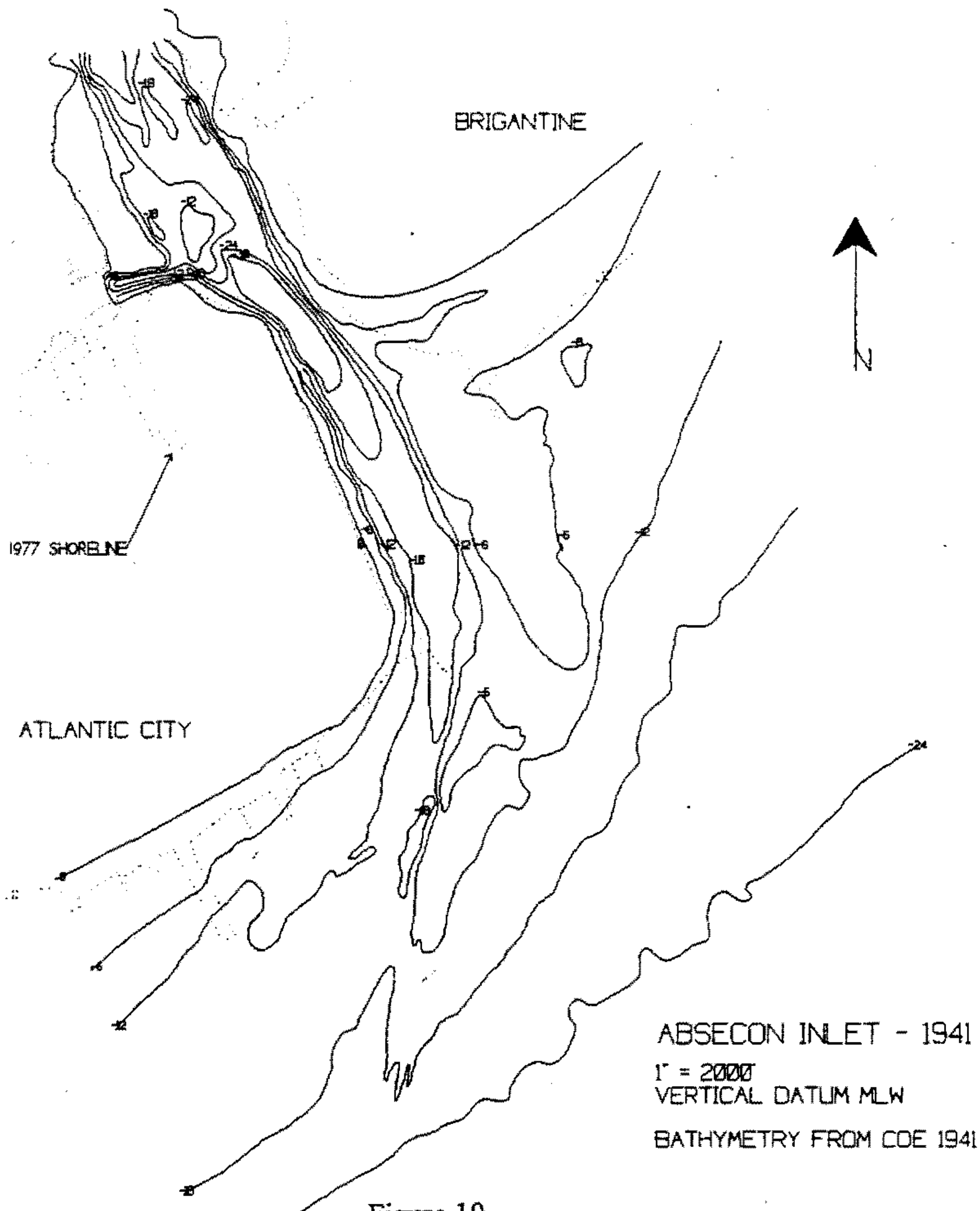


Figure 10

1941 Absecon Inlet Bathymetry

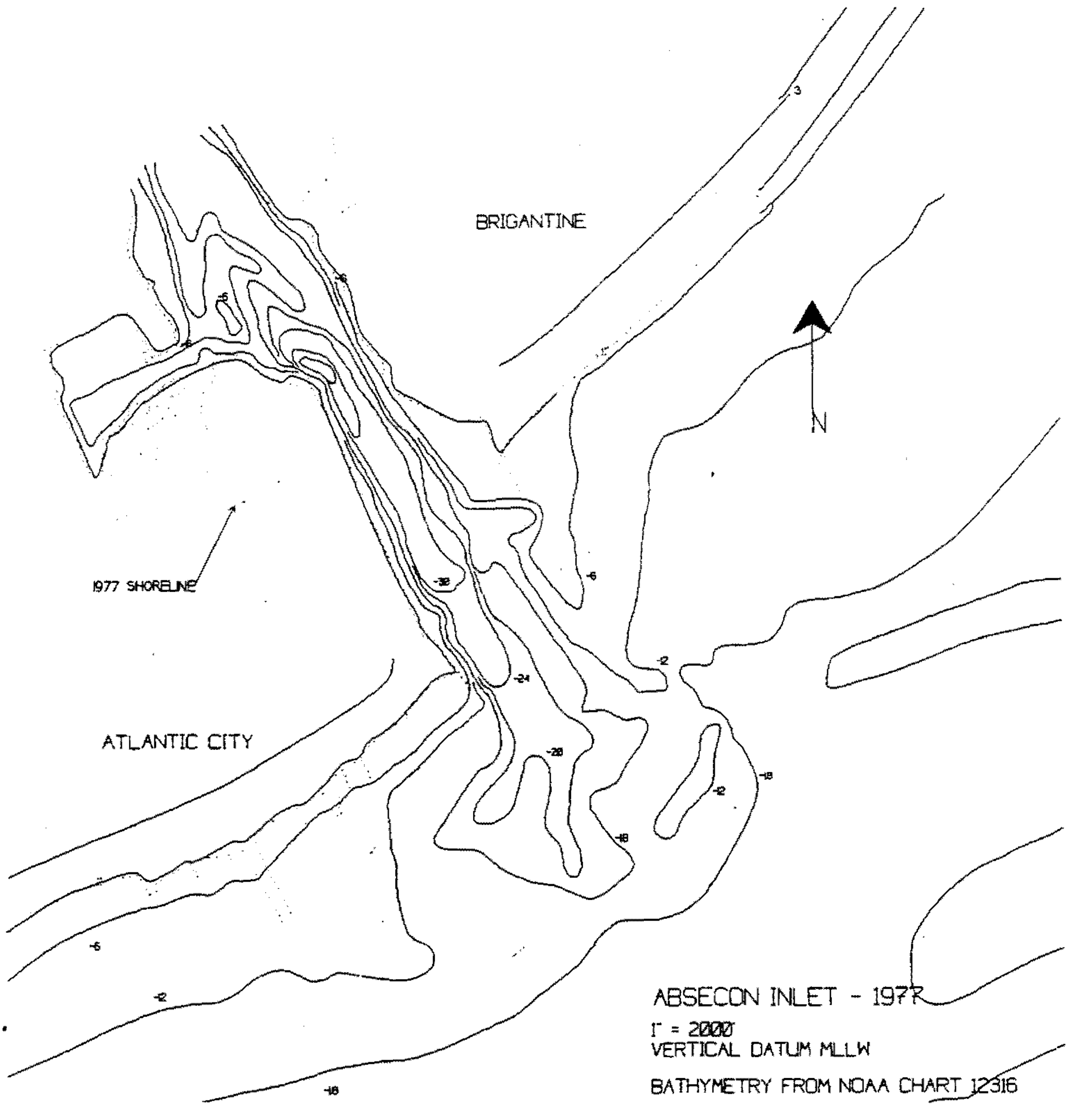


Figure 11

1977 Absecon Inlet Bathymetry

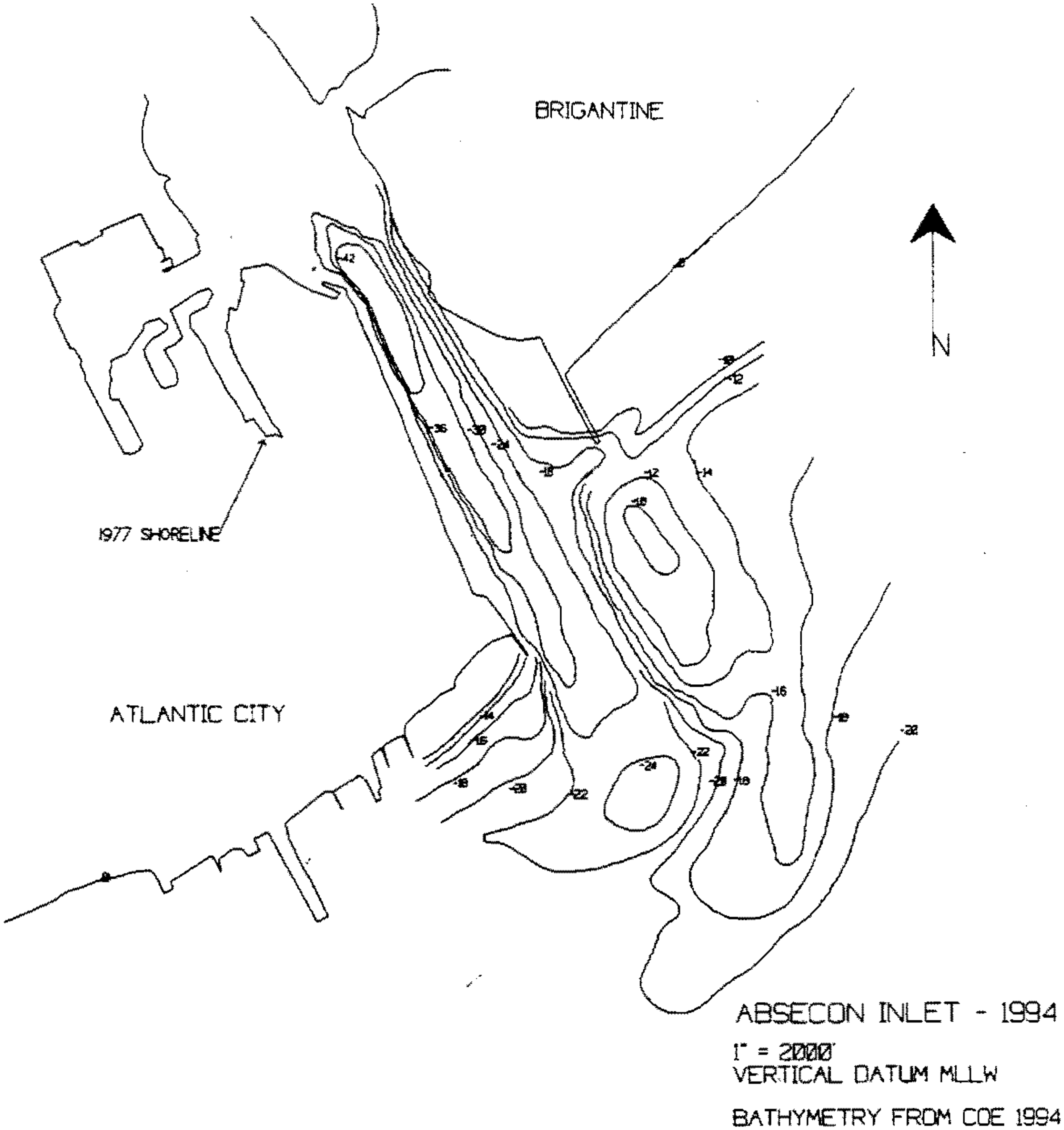


Figure 12

1994 Absecon Inlet Bathymetry

Table 14

ABSECON INLET: DREDGE HISTORY
from Annual Reports

FISCAL	YEAR	INLET NEW WORK (CY)	INLET MAINTENANCE DREDGING (CY)	INLET CUMULATIVE (CY)	CLAM CREEK NEW WORK (CY)	CLAM CREEK MAINTENANCE DREDGING (CY)
(CY)						
Project Dimensions 12' by 300'	1915	66,350		66,350		
	1916		358,961	425,311		
	1917		205,960	631,271		
	1918		180,970	812,241	15,350	
	1919		32,320	844,561		
	1920		9,300	853,861		
	1921		5,840	859,701		
	1922		209,649	1,069,350		
	1923		152,727	1,222,077		
	1924	692,866		1,914,943		
	1925	183,310		2,098,253		
	1926		0	2,098,253		
Project Dimensions 20' by 400'	1927		0	2,098,253		
	1928		0	2,098,253		
	1929		0	2,098,253		
	1930		0	2,098,253		
	1931		0	2,098,253		
	1932		0	2,098,253		
	1933		0	2,098,253		
	1934		0	2,098,253		
	1935		145,122	2,243,375		
	1936		800,567	3,043,942		
	1937		414,533	3,458,475		
	1938		612,877	4,071,352		
	1939		516,197	4,587,549		
	1940		328,956	4,916,505		
	1941		313,658	5,230,163		
	1942		0	5,230,163		
	1943		1,103,766	6,333,929		

Table 14 Continued

FISCAL YEAR	INLET			CLAM CREEK	
	NEW WORK	MAINTENANCE DREDGING	CUMULATIVE	NEW WORK	MAINTENANCE DREDGING
1944		512,110	6,957,879		
1945		111,840	6,846,039		
1946		123,896	7,081,775		
1947		7	7,081,775		
1948		7	7,081,775		
1949		709,479	7,791,254		
1950		503,560	8,294,814		
1951		0	8,294,814		
1952		221,725	8,516,539		
1953		138,621	8,655,160		
1954		143,251	8,798,411		
1955		306,193	9,10,4604		
1956		261,817	9,366,421		
1957		193,470	9,559,891	128,865	
1958		103,489	9,663,380		
1959		296,475	9,959,855		
1960		339,706	10,299,561		
1961		144,716	10,444,277		
1962		256,507	10,700,784		
1963		401,345	11,102,129		13,161
1964		222,522	11,324,651		
1965		348,961	11,673,612		
1966		129,502	11,803,114		
1967		83,552	11,886,666		
1968		122,796	12,009,462		
1969		153,070	12,162,532		
1970		148,502	12,311,034		14,136
1971		0	12,311,034		
1972		265,264	12,576,298		
1973		97,265	12,673,563		
1974		102,154	12,775,717		
1975		104,077	12,879,794		
1976		83,470	12,963,264		
1977		96,990	13,060,254		17,150
1978		0	13,060,254		

21

Table 14 Continued

FISCAL YEAR	INLET			CLAM CREEK	
	NEW WORK	MAINTENANCE DREDGING	CUMULATIVE	NEW WORK	MAINTENANCE DREDGING
1979		0	13,060,254		
1980		0	13,060,254		
1981		0	13,060,254		
1982		0	13,060,254		
1983		0	13,060,254		
1984		0	13,060,254		34,000
1985		0	13,060,254		
1986		0	13,060,254		
1987		0	13,060,254		
1988		0	13,060,254		
1989		0	13,060,254		
1990		0	13,060,254		
1991		0	13,060,254		
1992		0	13,060,254		
1993		0	13,060,254		
1994		0	13,060,254		

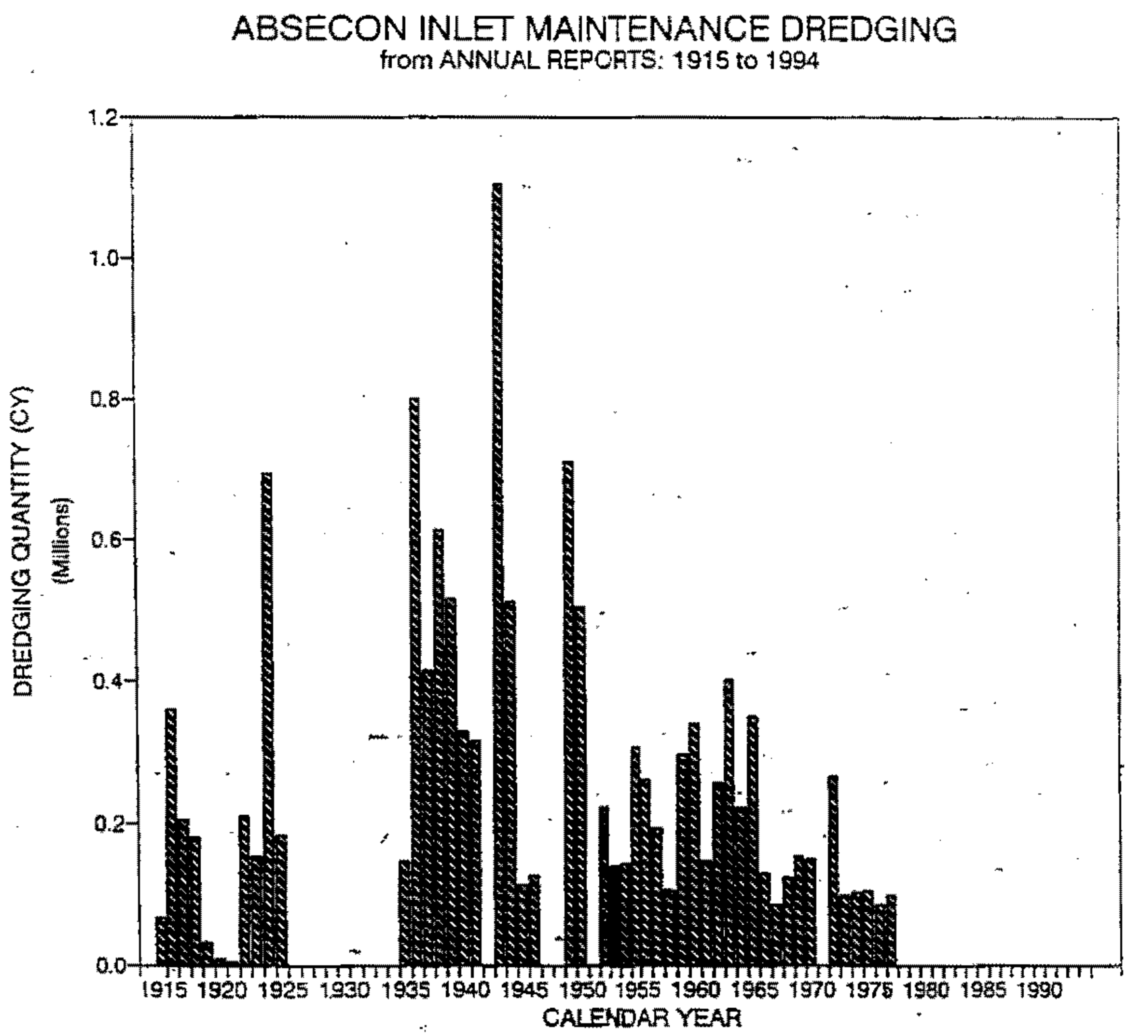

ABSECON INLET MAINTENANCE DREDGING
from ANNUAL REPORTS: 1915 to 1994
DREDGING QUANTITY (CY)
(Millions)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990
CALENDAR YEAR

Figure 13

194. Beach Fills. A summary of beach nourishment projects conducted from 1940 to 1994 on Absecon Island is provided in Table 15. The volume of material for each fill is considered a source or credit of material to the sediment budget analysis. The location of the borrow area for the respective fills must be examined and considered in the sediment budget computations.

Table 15
Summary of Beach Fill Projects on Absecon Island

Date Completed	Location of Fill	Quantity (cu yd)	Agency
1935-1943	Atlantic City (offshore berm)	3,554,000	USACE
1948	Atlantic City	1,073,000	USACE
March 1948	Atlantic City (Caspian to Oriental)	483,000	NJDEP
1963	Atlantic City (Oriental to Virginia)	560,000	NJDEP
1966	Atlantic City	125,000	USACE
July 1970	Atlantic City (Oriental to Illinois)	830,000	NJDEP
1978	Atlantic City (Illinois to Tennessee)		NJDEP
1979	Atlantic City	48,160	USACE
June 1983	Atlantic City (Massachusetts to Vermont)	43,000	NJDEP
June 1983	Atlantic City (Michigan to St. James)	32,000	NJDEP
June 1986	Atlantic City (Oriental to Arkansas)	1,000,000	NJDEP
1990	Longport	250,000	NJDEP

195. Coastal Structures. Coastal structures such as groins and jetties can have an effect on the sediment budget by trapping a portion of the littoral drift. Other structures present on Absecon Island, such as piers and outfalls, may have small effects on longshore transport processes depending on the density of their substructure. The terminal groin at Longport has had a significant effect on the southern portion of Absecon Island. The groin functions as a sediment

trap for material which otherwise would have been lost to the Great Egg Harbor Inlet complex.

196. SEDIMENT BUDGET ANALYSIS PROCEDURES. The following paragraphs describe the development of the sediment budget for Brigantine Inlet to Great Egg Harbor Inlet. The detailed sediment budget is provided in Appendix A.

197. The selection of the specific time periods for analysis was dependent on the availability of shoreline position data and wave data for the study area during the general period of interest between 1950-1993. Review of the available data indicated that shoreline position data for 1952, 1977 and 1986 were available from a database developed by Dr. Steve Leatherman of the University of Maryland Laboratory for Coastal Research. In addition, shoreline position data for 1993 based on digital orthophoto mapping of significant segments of the study area shoreline were also available.

198. Available wave data for the study area included Wave Information Study (WIS) hindcasts for the period 1956-1975 calculated at 3 hour intervals. In addition, wave hindcasts for the period 1987-1993 developed by Offshore & Coastal Technologies, Inc. (OCTI) for the Philadelphia District at 3 hour intervals near the WIS station were available.

199. Based on the availability of shoreline position and wave data, the specific periods of analysis for the sediment budget were selected to include:

1952-1977
1977-1986
1986-1993

Seven control volumes for the sediment budget analysis were selected. The first control volume is Little Beach, which is located at the northern end of the study area, extending from Little Egg Inlet south for 2.7 miles to Brigantine Inlet. This control volume provides the source of longshore sand transport into Brigantine Inlet from the north which results in potential inlet shoaling and potential sand bypassing to the Brigantine Island shoreline. An assumption is made that there is negligible sand bypassing from Brigantine Inlet across the southern boundary into this control volume.

200. The second control volume is Brigantine Inlet. Potential significant sand inputs to this control volume are assumed to be southerly sand transport from the north and northerly sand transport from the Brigantine Island shoreline. Potential sand outputs from this control volume are dredging, shoal growth, sand bypassing to the Brigantine oceanfront shoreline, and offshore losses.

201. The third control volume, Brigantine Island, extends from Brigantine Inlet south for 6.3 miles to the stone jetty at the southern end of Brigantine at Absecon Inlet. Potential sand inputs to this control volume are sand bypassing from Brigantine Inlet, shoreline erosion, and beach fills. Potential sand outputs from this control volume are northerly longshore sand transport across the

northern boundary into Brigantine Inlet, southerly longshore transport across the southern boundary into Absecon Inlet, offshore losses, and shoreline accretion. Significant events in this control volume include a 393,000 cubic yard beach fill in 1962, a 175,000 cubic yard beach fill in 1963, a 66,000 cubic yard beach fill in 1966, and jetty construction and extensions in 1952, 1959, and 1974.

202. The fourth control volume, Absecon Inlet, extends from the southern boundary of the Brigantine Island control volume south to a southern boundary at the stone jetty in Atlantic City. Potential sand inputs to this control volume are southerly longshore transport across its northern boundary from Brigantine Island and northerly longshore transport across the southerly boundary from Atlantic City. Potential sand outputs are dredging, sand bypassing to Atlantic City, shoal growth, and offshore losses. The most significant events in this control volume are the annual dredgings between 1952-1972 and the 1,000,000 cubic yard dredging for beach fill in 1986.

203. The fifth control volume, Absecon Island, extends from the northern boundary at Absecon Inlet south 8.0 miles to a southern boundary at the jetty at the southern end of Longport at Great Egg Harbor Inlet. Potential sand inputs to this control volume are sand bypassing across Absecon Inlet, shoreline erosion loss and beach fills. It is assumed that there is negligible sand bypass into this area from the Ocean City shoreline. Potential sand outputs include northerly longshore transport across the northern boundary into Absecon Inlet, southerly longshore transport across the southern boundary into Great Egg Harbor Inlet, shoreline accretion, and offshore losses.

204. The sixth control volume, Great Egg Harbor Inlet, extends from the southern boundary of the Absecon Island control volume to the northern end of Ocean City. Potential significant sand inputs to this control volume are assumed to be southerly sand transport from the Absecon Island area and northerly sand transport from the Ocean City shoreline. Potential sand outputs from this control volume are dredging, shoal growth, sand bypassing to the Ocean City oceanfront shoreline, and offshore losses.

205. The seventh control volume, Ocean City, extends from the northern boundary at Great Egg Harbor Inlet south 1.0 mile along the Ocean City shoreline. Potential sand inputs to this control volume are sand bypassing across Great Egg Harbor Inlet, shoreline erosion and beach fills. Potential sand outputs include northerly longshore transport across the northern boundary into Great Egg Harbor Inlet, southerly longshore transport across the southern boundary, shoreline accretion, and offshore losses.

206. One of the important components of the sediment budget analysis is the determination of the potential longshore sand transport which is an estimate of the maximum capacity of the breaking waves to carry sand alongshore in the presence of an unlimited supply of movable material. For this analysis, the GENESIS shoreline change model was used to develop the potential longshore sand transport rates along the study area shoreline. Local variations in longshore transport due to shoreline orientation changes were accounted for by applying the modeling using 215 ft. alongshore grid spacings for each of the four control volumes subject to longshore sand transport, Pullen Island, Brigantine Island, Absecon Island, and Ocean City. Hindcast wave data at 3 hour

intervals from 1987-1993 and the internal wave transformation routine in GENESIS were used to develop the potential longshore transport rates along each of the control volume shorelines. The longshore transport rates were averaged for the 6 year period for use in the sediment budget analysis. This procedure provided the average potential longshore sand transport rate to the left and to the right at each of the boundaries of the control volumes.

207. Volumetric shoreline changes were developed for each of the control volumes for each analysis period using historical shoreline change maps. Shoreline changes were converted to volumetric changes using a volumetric equivalent factor which assumes that the entire active profile moves at the same rate as the shoreline. For the purposes of this analysis, it was assumed that one foot of shoreline movement was equivalent to 1.0 cu yd/l ft of shoreline. Overall volumetric changes in each control volume were developed by determining the change in area between the respective shorelines at the 215 ft interval grid cells used in the GENESIS model for longshore sand transport calculations. The area changes were then converted to volume changes using the volumetric equivalent factor.

INLET PROCESSES AT ABSECON INLET

208. A history of general inlet geometry change for Absecon Inlet is available in "A Summary Document for the Use and Interpretation of the Historical Inlet Bathymetry Change Maps for the State of New Jersey," (Farrell, et. al., 1989). This section describes the findings of historical inlet shoreline change maps from the mid 1800s to the 1980s.

209. HISTORICAL PROCESSES. In addition to the inlet shoreline change descriptions discussed in Farrell, et. al. (1989), there is also an extensive discussion of pre-jetty inlet processes and shoreline erosion and deposition in Fitzgerald (1981). The processes described in this report have changed considerably due to the construction of the jetty and extensive dredging of the inlet for navigation, however valid historical information is provided.

210. In general, pre-jetty inlet processes are typical of most inlets on the southern coast of New Jersey (Figure 14). Longshore transport is to the south, with a seaward offset of the southerly barrier island. Sediment is deposited into the inlet tidal channel and updrift ebb tidal shoal by longshore transport. Sediment deposited in the tidal channel is carried seaward by ebb tidal currents and dispersed over the ebb tidal shoal. A portion of this material is then carried back into the channel by wave action. This deposition into the channel from the updrift side causes the channel to migrate to the downdrift, or southerly, side of the inlet, causing erosion along the southerly inlet facing shoreline. As the ebb tide shoal migrates to the south under the influence of waves and tidal currents, the seaward end of the main tidal channel bends around the northern end of the southerly barrier island, depositing large quantities of sediment seaward of the ocean facing beach. This deposition helps form and maintain the seaward offset of the downdrift island, by providing protection from storm waves and providing a source of sand which migrates landward, causing accretion on the ocean facing beach.

211. Accretion of material in the outer ebb shoal eventually causes the inlet channel to become hydraulically inefficient and a new channel is cut through the shoal more directly to the ocean. As the old channel fills in, the ebb shoal on the landward side of the new channel migrates landward and causes a temporary accretion along the northern end of the southerly barrier island. The southerly channel-facing beach also accretes due to movement of the channel away from the shoreline. As ebb currents deposit material at the seaward end of the new channel location, sediment seaward of the northern end of the southerly barrier island dissipates and moves shoreward at a reduced rate. The shoal which protected the end of the island begins to be reduced in elevation. Both onshore sediment supply is reduced and wave attack is increased leading to shoreline erosion in this location.

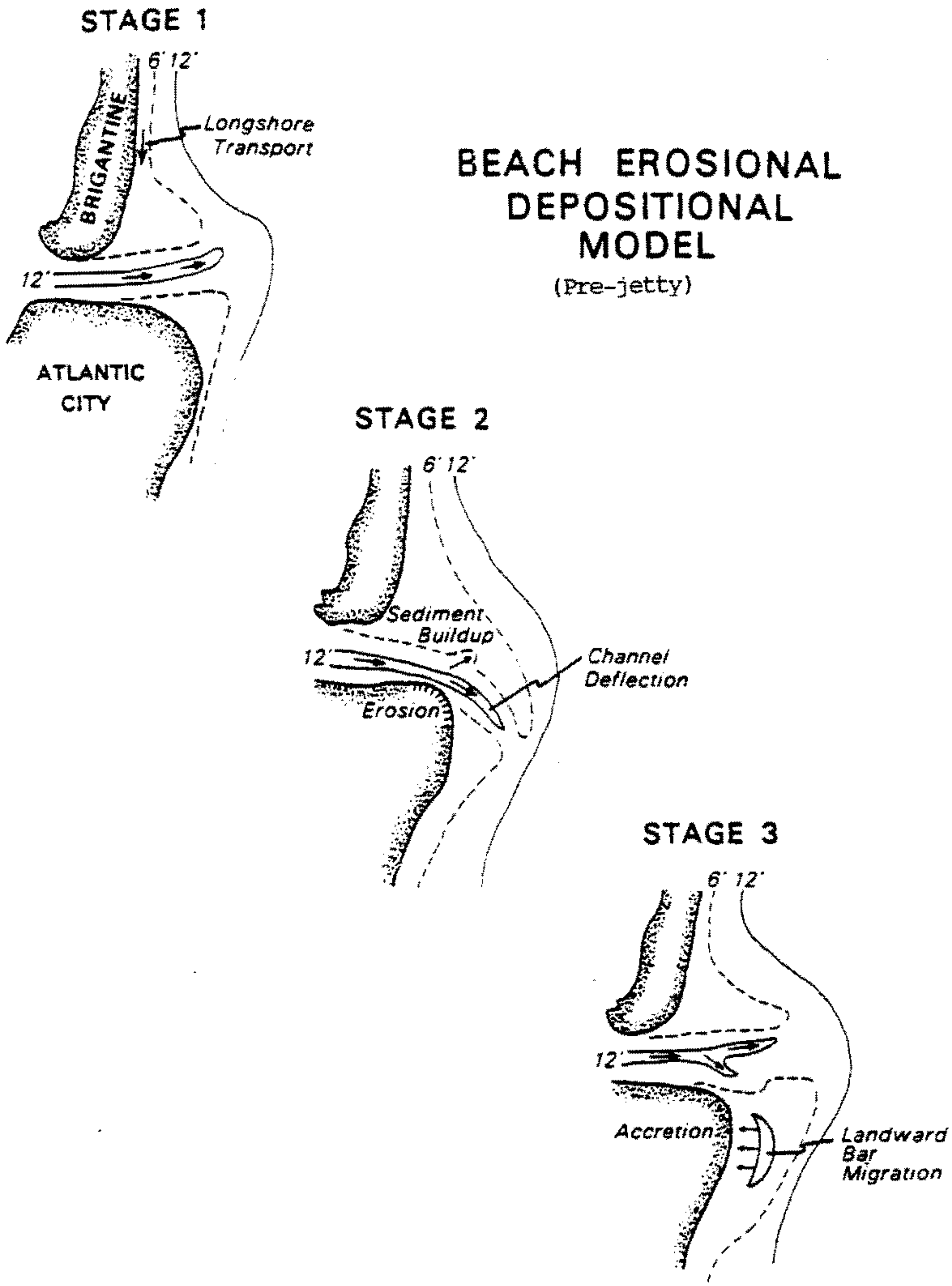

STAGE 1
6' 12'
BRIGANTINE
Longshore Transport
12'
ATLANTIC CITY
BEACH EROSIONAL DEPOSITIONAL MODEL
(Pre-jetty)
STAGE 2
6' 12'
Sediment Buildup
12'
Channel Deflection
Erosion
STAGE 3
6' 12'
12'
Accretion
Landward Bar Migration

Figure 14

212. Concurrently, continued updrift channel infilling causes the new channel to migrate to the south, repeating the cycle. The periodicity of the channel migration and breakthrough cycle depends on the distance the channel moves, and the amount of material which must be eroded and redeposited each cycle. Fitzgerald (1981) estimates that historically (pre-jetty) Absecon Inlet had a 10 to 20 year cycle of channel movement. This is similar to Townsends Inlet, where the seaward end of the channel breaks through the ebb shoal in a more northerly channel and then migrates to the south on a frequent basis. Hereford Inlet, on the other hand, has a very long period natural channel migration and island erosion/deposition cycle of approximately 60 years, because of the much greater width of the inlet and the greater migration distance of the channel.

213. PRESENT DAY PROCESSES. Since dredging began at Absecon Inlet in 1915, and especially since the jetty construction in the mid 1950s, the channel has remained relatively stable. A deep channel extends seaward from the mouth of the inlet defined by the Brigantine Jetty on the north and the inlet shoreline and the Oriental Street Jetty on the south. Dredging has, in the past, maintained a channel alignment extending straight out from the inlet mouth. Since maintenance dredging was discontinued in 1977, the channel has migrated somewhat to the south due to the intrusion of the updrift ebb tidal shoal.

214. Present day inlet sedimentation processes are as follows. A schematic diagram of the predominant sediment pathways is shown in Figure 15. Net longshore transport carries material from the north until it reaches the Brigantine Jetty. A portion of the material is carried past the jetty either by flow over the jetty, infiltration through the jetty, or by wind, and is deposited into the interior shoals adjacent to the jetty on the north side of the channel. From there the material is carried into the inlet by longshore transport to the north until it is intercepted by tidal currents and carried back seaward by ebb tide flows. Since the interior shoals appear to be in equilibrium, based on historical bathymetry, additional material is not presently being stored in the shoal, so that the quantity of material picked up by the tidal currents equals the amount of sediment passing the jetty. The remainder of the longshore transport passes around the end of the jetty, carried by wave action and flood tide currents, and is deposited in the tidal channel or outer ebb tide shoal. Material on the shoal is transported landward by wave action until it is deposited in the tidal channel. Material deposited in the tidal channel is carried seaward by the ebb tide current and dispersed over the seaward end of the channel.

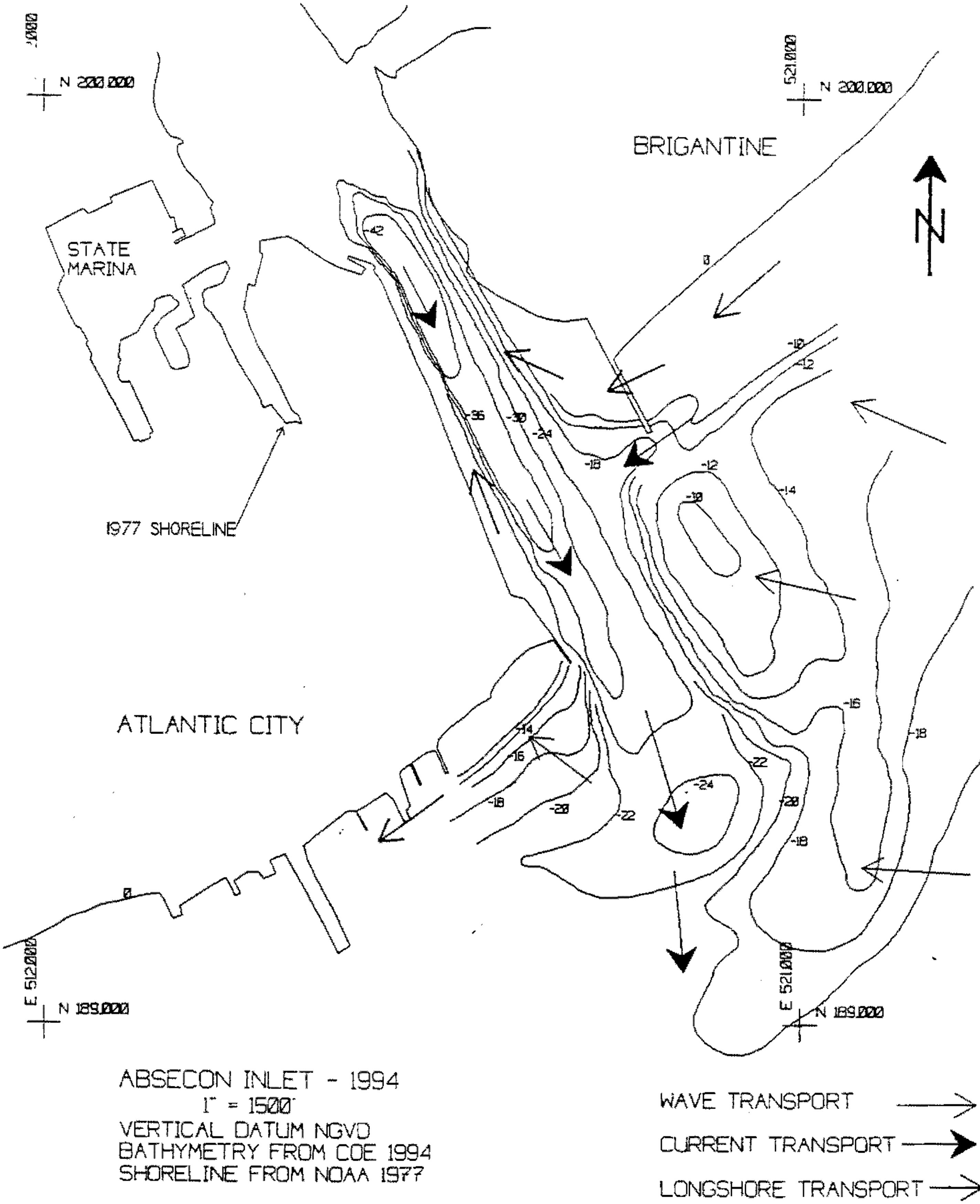


Figure 15 Sediment Pathways

215. Figures 16 through 19 show ebb and flood currents for a spring tide condition for both the 1994 and 1977 bathymetries. It can be seen that relatively strong currents exist to several thousand feet offshore. Due to extensive dredging in Absecon Inlet since 1915 (approximately 14 million cubic yards removed over 80 years), the ebb tidal shoals have been greatly depleted and the shoals are much deeper than typical southern New Jersey inlet shoals. However, a portion of the sediment carried seaward by the tidal currents is deposited in relatively shallow depths seaward of the Atlantic City beaches, where it is carried landward onto the beach by wave action.

216. The remainder of the material which is carried seaward by the ebb currents is spread out over the sea floor over a large area. Due to the large tidal currents and lack of ebb tidal shoals, the material appears to be carried further seaward than at other southern New Jersey Inlets. Based on the sediment budget and the existence of extensive linear shoals seaward and north of Absecon Inlet, it is believed that significant quantities of sand are transported offshore and lost to the nearshore system.

217. Figure 20 shows the net wave sediment transport potential at Absecon Inlet. It can be seen that the wave transport is to the west, and is strongest over the shallow shoals and nearshore contours. The onshore wave transport is responsible for the formation of the shoal defined by the -10 foot contour seaward of the Brigantine Jetty, as well as the deeper shoals seaward of the end of the ebb tidal channel. The waves tend to return sand landward which has been carried offshore by the ebb currents. However, as noted above, it appears likely that the wave transport is not sufficiently strong over the dredged shoal area to return all of the material back to shore, resulting in a loss of material from the inlet shoal area. Figure 21 further shows wave sedimentation patterns, as defined by the gradient in the wave transport potential. Again it can be seen that the areas of strongest potential sediment movement is in the shallow water areas.

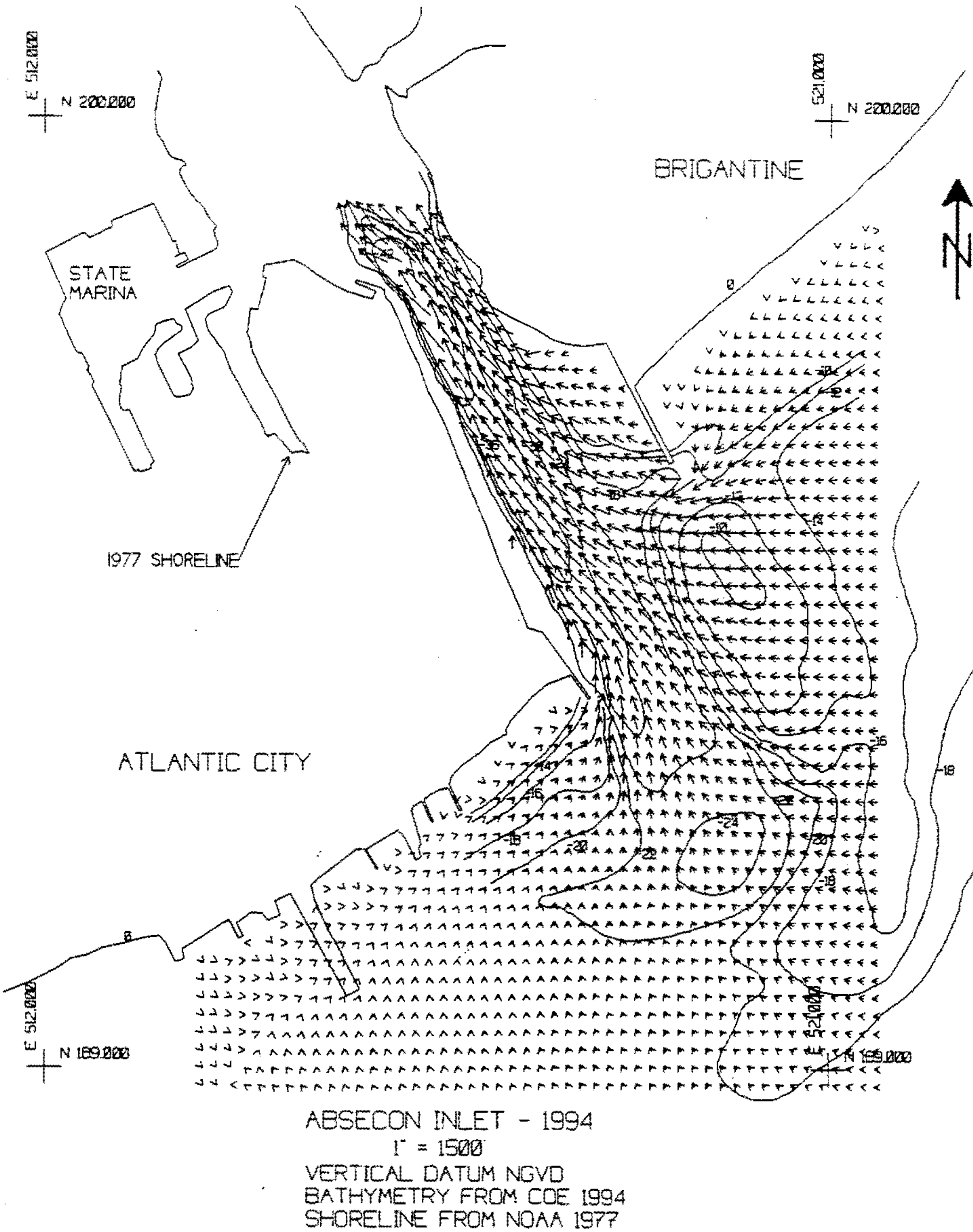


Figure 16 Absecon Inlet Current Field, Flood Tide, 1994

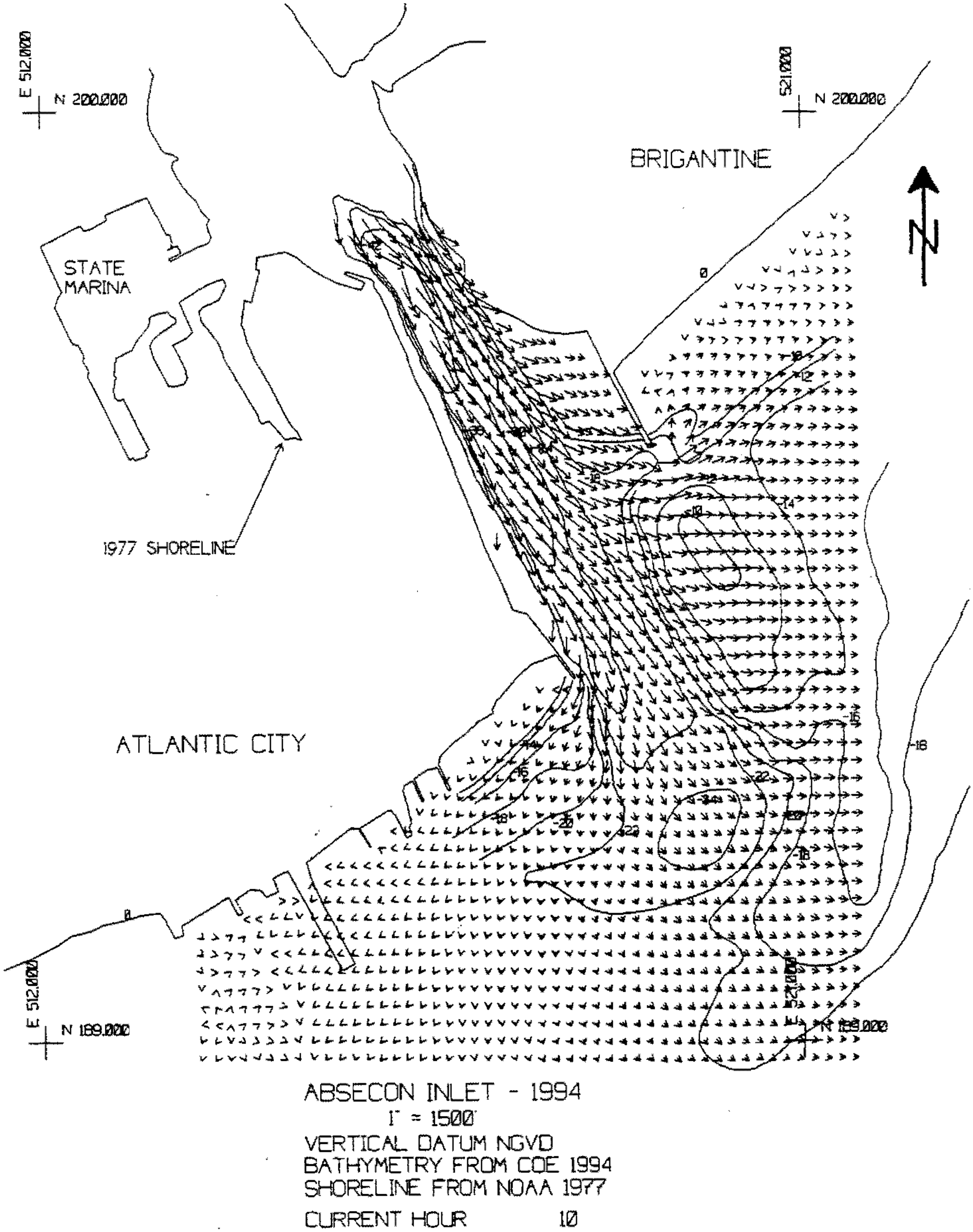


Figure 17 Absecon Inlet Current Field, Ebb Tide, 1994

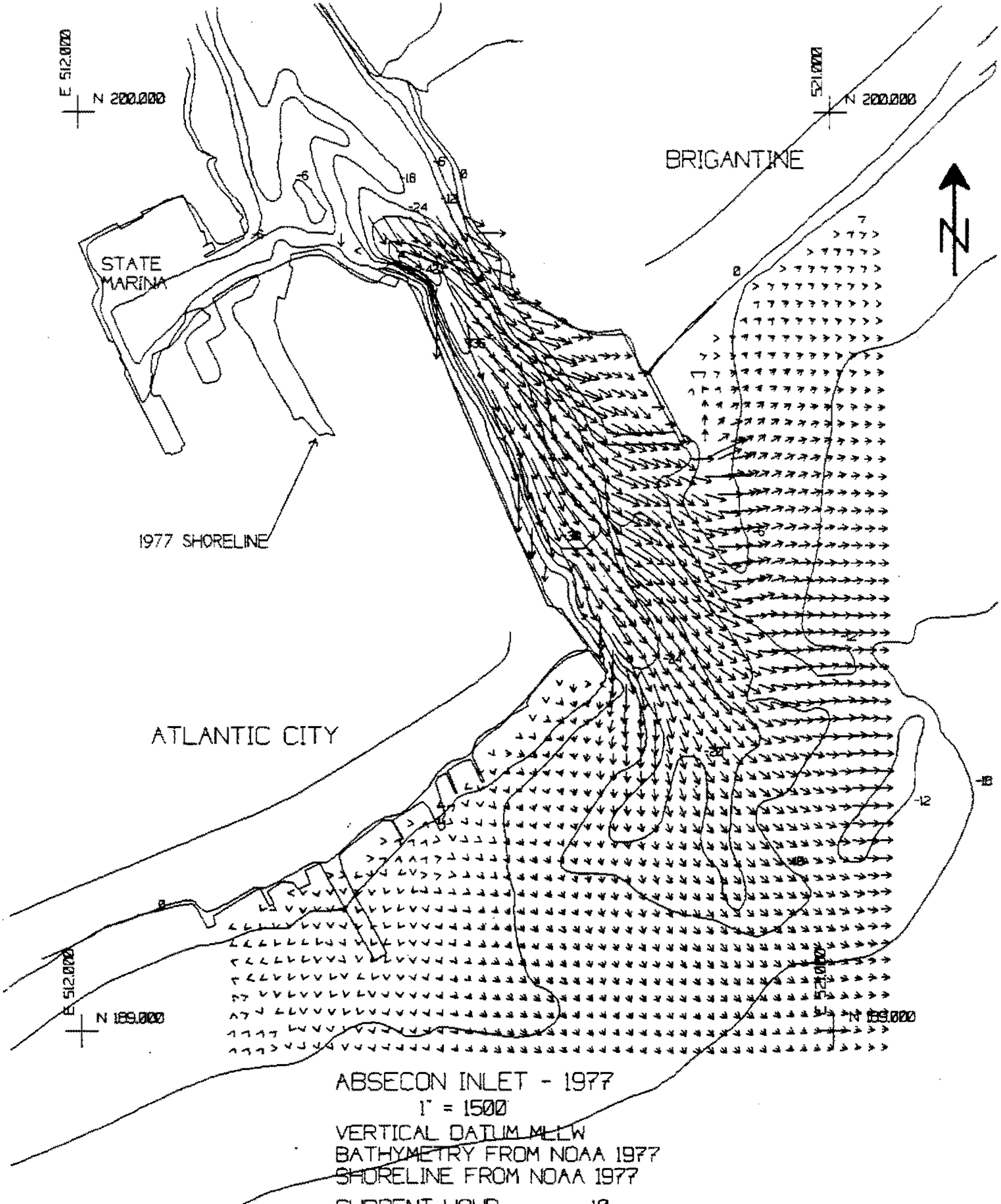


Figure 19 Absecon Inlet Current Field, Ebb Tide, 1977

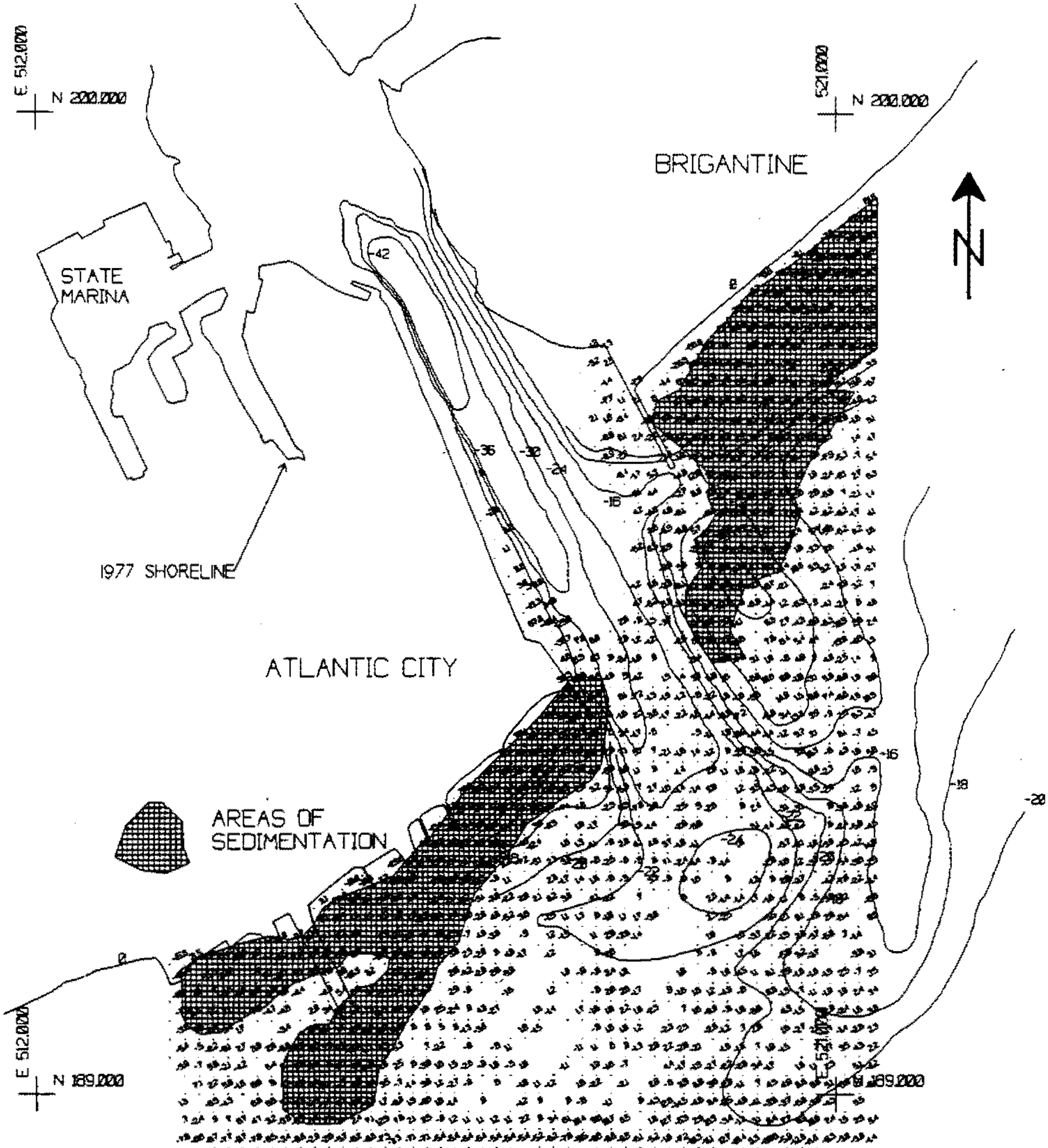


Figure 21

ABSECON INLET - 1994
1" = 1500'
VERTICAL DATUM NGVD
BATHYMETRY FROM COE 1994
SHORELINE FROM NOAA 1977

WAVE SEDIMENTATION
PATTERNS

218. FUTURE CONDITIONS. Based on the assumption that at the present time a significant portion of the longshore transport entering Absecon Inlet from the north is being lost offshore due to high ebb tidal currents, as opposed to bypassing the inlet to the southern shoreline or being stored in inlet shoals, future conditions in the inlet can be projected. Without future dredging for navigation or beach fill borrow, it is likely that the deep shoals to the north of the existing channel will grow over time, and continue to wrap around the channel and deflect the main ebb channel to the south. This is based on results of the wave modeling and analysis of historical patterns of sedimentation in Absecon Inlet and other southern New Jersey Inlets. However, due to the continuing loss of material offshore, this buildup of the ebb tidal shoals will be slow. It is anticipated that without dredging, over the span of the next 20 years the ebb tidal shoals will begin to increase sufficiently to reduce inlet flows and ebb tidal current velocities. As ebb currents are reduced in velocity and deflected further southward, less material will be lost offshore and the rate of buildup of the shoals will increase.

219. Therefore, without future dredging, Absecon Inlet could have significant ebb tidal shoals at the end of a 50-year project period. The larger ebb shoal would provide additional protection from waves for the nearshore areas, and increase natural bypassing to the Absecon Island shoreline. In time, the inlet would re-establish its original sediment processes, as described in the Historical Processes section. However, this would not occur until the end of the 50-year period or beyond.

220. Due to the importance of the inlet to local commercial and recreational navigation, it is unlikely that ebb tidal shoals will be allowed to accumulate sufficiently to block the navigation channel. If navigation dredging takes place, the ebb currents will continue to transport material offshore out of the inlet system. Additional dredging for beach nourishment will also tend to prevent the buildup of the ebb shoals, and will therefore maintain the present condition of minimal natural bypassing and loss of material offshore. Depending upon the rate of inlet dredging, the shoals may increase in volume in the future and provide a partial decrease in wave attack at the shoreline; however, this effect is expected to be minor if the inlet is maintained with a navigation channel with a depth greater than 20 feet.

SHORELINE CONDITIONS

221. HISTORIC SHORELINE CONDITIONS. A historic shoreline analysis of Absecon Island was conducted for the Atlantic Ocean and Absecon Inlet shorelines. This analysis documents past behavior and "background" conditions of the shoreline and determines long-term erosion rates where applicable in the study area. This rate can vary significantly depending on the time period analyzed.

222. <u>Data Sources.</u> The historic shoreline analysis relied on four principal types of information: aerial photography, onshore/offshore beach profiles, digital shoreline change maps, and previous reports. The aerial photography utilized for Absecon Island included the following dates: 1955, 1962, 1964, 1970, 1984, 1985, 1988, and 1993. Most of the aerial photography is vertical black-

and-white at a contact scale of 1 inch equals 400 feet. Ground-level photography was obtained in 1988 to provide a detailed documentation of shoreline conditions and protective structures.

223. Beach profiles in Atlantic City have been monitored by the Corps of Engineers in a variety of locations since 1936. Beginning in 1955, a series of a profile line locations was established along the entire ocean and inlet frontage of Absecon Island, including Atlantic City, Ventnor, Margate, and Longport. This series of profile lines was surveyed in 1955, 1962, 1965, 1988, 1993, and 1994. There are two historic profile lines on the Absecon Inlet frontage; six on the ocean shoreline of Atlantic City, three in Ventnor, four in Margate, and four in Longport. The profile lines typically extend from the landward crest of the beach profile (i.e., top of dune or, where present, top of bulkhead) seaward out to the 30 ft depth contour. In order to better document shoreline conditions for purposes of this feasibility study, the 1993 and 1994 beach surveys were expanded to include more survey lines across Absecon Island. Most of these additional transects replicate lines surveyed as part of the New Jersey State Beach Profile Network. A total of 22 profile lines were surveyed in August 1993, providing a typical "summer beach" condition and in March/April 1994, providing a typical "winter beach" condition. Figure 2 showed the locations of the various profile lines. Cross-sectional plots of the August 1993 profiles are provided in Appendix A.

224. Historic shorelines of Absecon Island were digitally mapped as part of the New Jersey Historical Shoreline Map Series (Farrell and Leatherman, 1989). These maps include shorelines from 1836-42, 1871-75, 1899, 1932-36, 1951-53, 1971, 1977, and 1986. The shoreline from 1993 was subsequently added as part the photogrammetry work done for this study. The shoreline represents mean high water as determined from the digital terrain map. The shoreline maps provide a beneficial overview of shoreline conditions through time. However, it is difficult to evaluate and differentiate natural shoreline evolution from the effects of development and coastal protection projects (such as beach fills and coastal structures). The numerous beach fills placed on the northern end of Atlantic City since 1948 must be accounted for when evaluating shoreline behavior from these maps.

225. Reports pertinent to Absecon Island were compiled and reviewed for this analysis. This information was used to develop a qualitative, and where possible, quantitative understanding of historic behavior of the Absecon Island ocean and inlet shorelines. These reports include:

House Document 81-538, "Atlantic City Beach Erosion Control Study", 1950;

House Document 86-208, "Shore of New Jersey - Barnegat Inlet to Cape May Canal, Beach Erosion Control Study", 1959;

House Document 88-298, "Atlantic City, New Jersey: Interim Hurricane Survey", 1964;

House Document 88-325, "Atlantic City, New Jersey, Beach Erosion Control Study", 1964;

House Document 94-631, "New Jersey Coastal Inlets and Beaches - Barnegat Inlet to Longport", 1976;

New Jersey Shore Protection Master Plan", Dames and Moore, for NJDEP, 1981;

"Coastal Geomorphology of New Jersey", Karl F. Nordstrom, Rutgers Center for Coastal and Environmental Studies, 1977;

"Behavior of Beach Fill at Atlantic City, New Jersey", Everts et al., U.S. Army Engineer Coastal Engineering Research Center, CERC Reprint 12-74, 1974;

"Beach Changes Caused by the Atlantic Coast Storm of 17 December 1970", DeWall, et al., U.S. Army Engineer Coastal Engineering Research Center, Technical Paper 77-1, 1977;

"Beach Changes at Atlantic City, New Jersey (1962-73)", Dennis P. McCann, U.S. Army Engineer Coastal Engineering Research Center, Miscellaneous Report 81-3, 1981;

"Evaluation of Beach Behavior and Coastal Structure Effects at Atlantic City, NJ," Robert M. Sorensen and J. Richard Weggel, for NJDEP, 1985;

"Monitoring and Evaluation of 1986 Beach Nourishment, Atlantic City, New Jersey," Robert M. Sorensen, J. Richard Weggel, and Scott M. Douglass, for NJDEP, 1989.

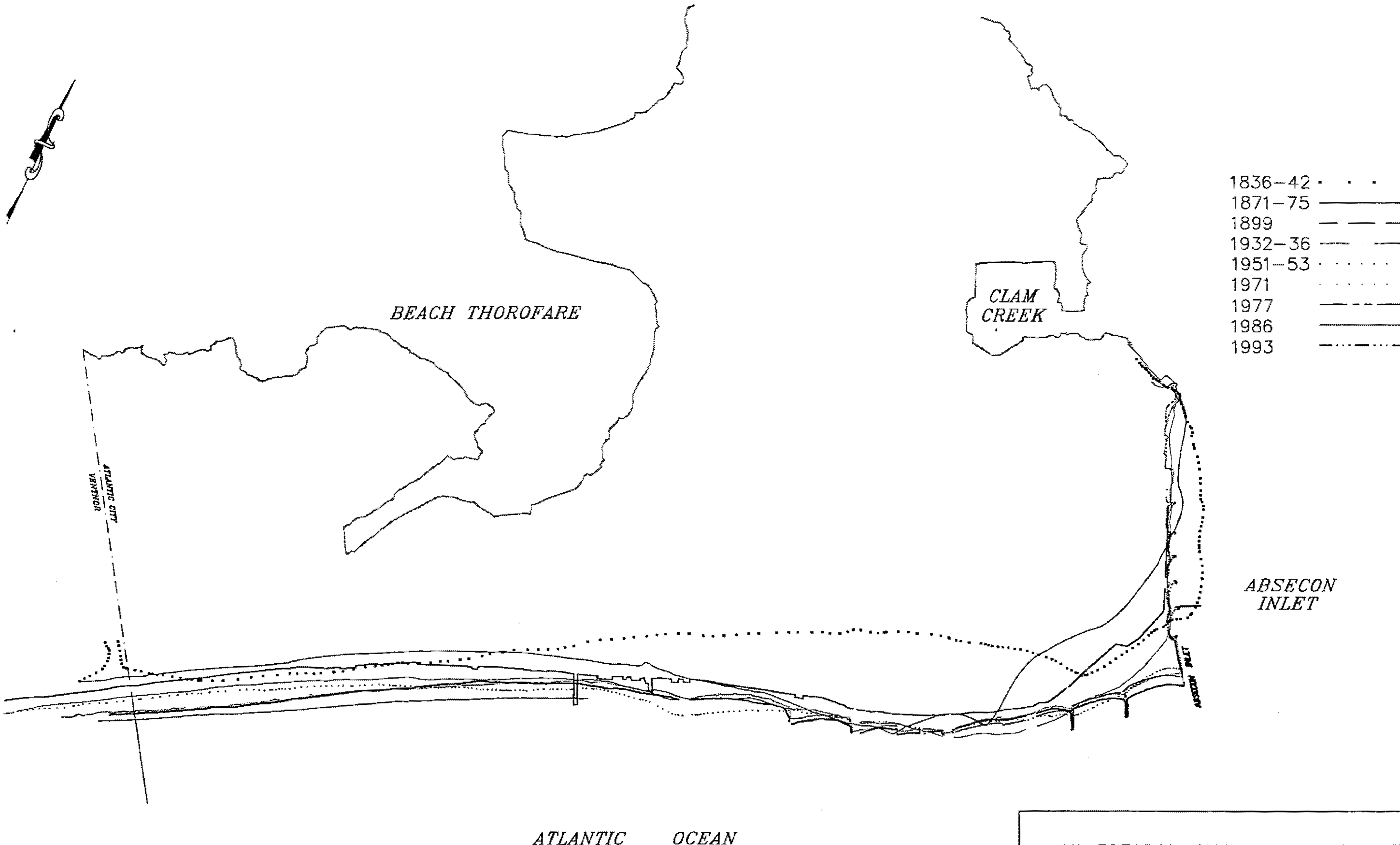
"New Jersey Beach Profile Network Analysis of the Shoreline for Reaches 1-15, Raritan Bay to Stow Creek," Stewart C. Farrell et al., for NJDEP, 1993.

226. Summary of Historical Shoreline Conditions. Figure 22 provides an overview of shorelines through time from Absecon Inlet to Great Egg Harbor Inlet and vicinity, including Atlantic City, Ventnor, Margate and Longport. Historically, the most dynamic section of shoreline is located approximately two miles south of Absecon Inlet. This reach experienced significant landward-seaward oscillations prior to construction of shore stabilization structures (primarily in the 1930's and 1940's). For example, between 1842 and 1877 shoreline movements as large as 1500 ft have occurred (McCann 1981). Construction of groins and the Oriental Avenue jetty have greatly reduced such extreme shoreline fluctuations; however, the trend in this portion of Atlantic City over the past four decades has been progressive erosion countered by periodic beach nourishments (Sorensen, Weggel, and Douglass 1989).

227. The Atlantic City shoreline along Absecon Inlet progressively receded from 1836 to 1899. The inlet shoreline has essentially remained in a similar location from 1899 to 1993 (Figure 22A). Minimal beach exists in this area, and consists mostly of small fillets of material in the vicinity of the Maine Avenue groins. Channel locations relative to the inlet shoreline and natural inlet bypassing processes are further discussed in subsequent sections on the sediment budget for

Absecon Island and shoaling analysis for Absecon Inlet.

228. Historically, shoreline change along Ventnor, Margate, and Longport has not been evaluated to the same extent as shoreline behavior in Atlantic City. The numerous beach fills in Atlantic City have most likely contributed to the accretionary behavior of the downdrift shorelines along Absecon Island. Analysis of shoreline change maps shows that the Ventnor shoreline has generally been accretionary from 1836 to the present (Figure 22B). Although more variable through time, the overall trend along the Margate shoreline has been one of accretion. Beach width has historically been largest in northern Margate and decreases to the south.



Note: This map was developed, in part, using New Jersey Department of Protection Geographic Information System digital data, but has not been verified by NJDEP.

HISTORICAL SHORELINE CHANGES
ABSECON ISLAND, NJ
ATLANTIC CITY
SCALE: NTS

Figure 22 A

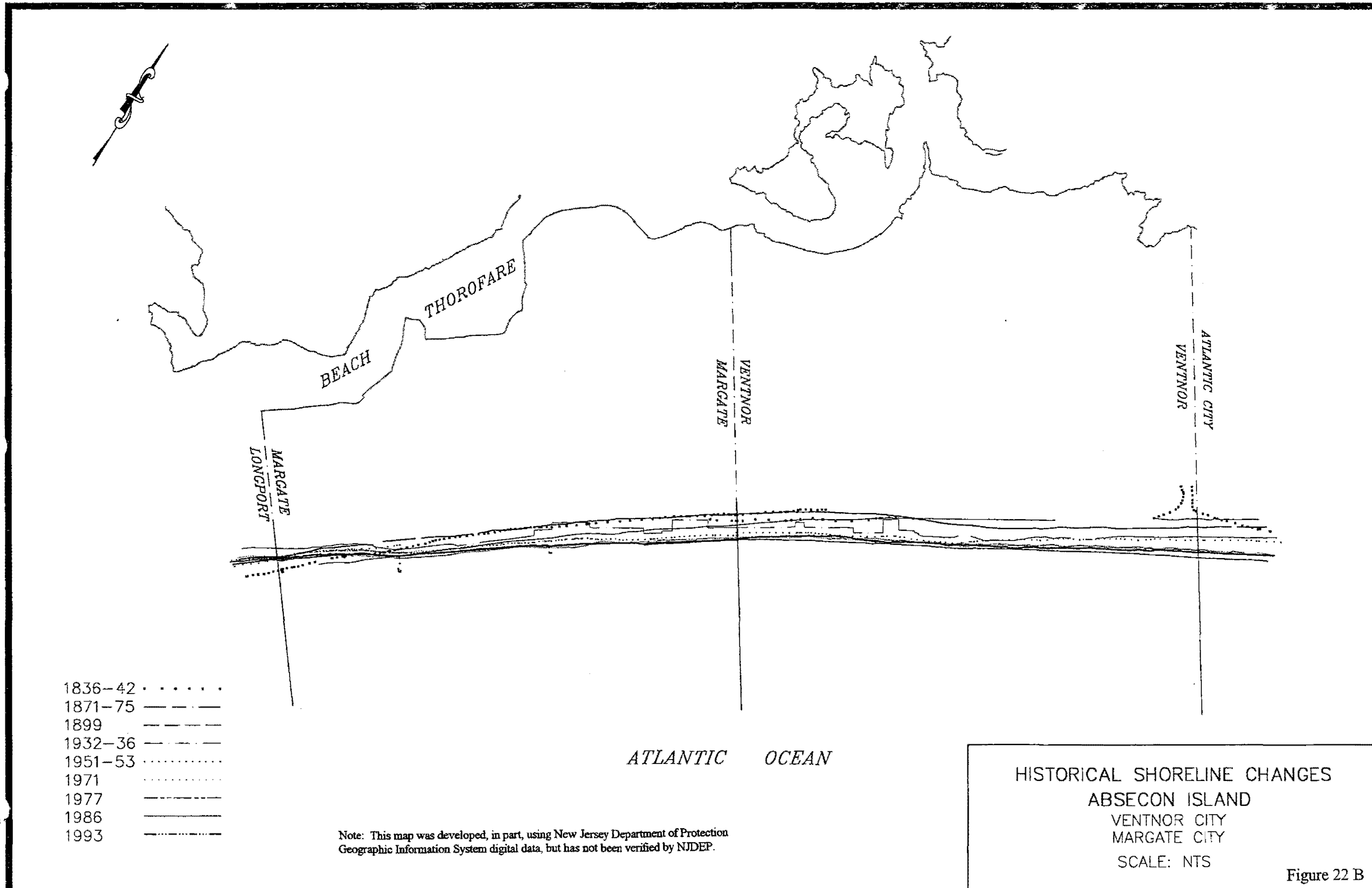
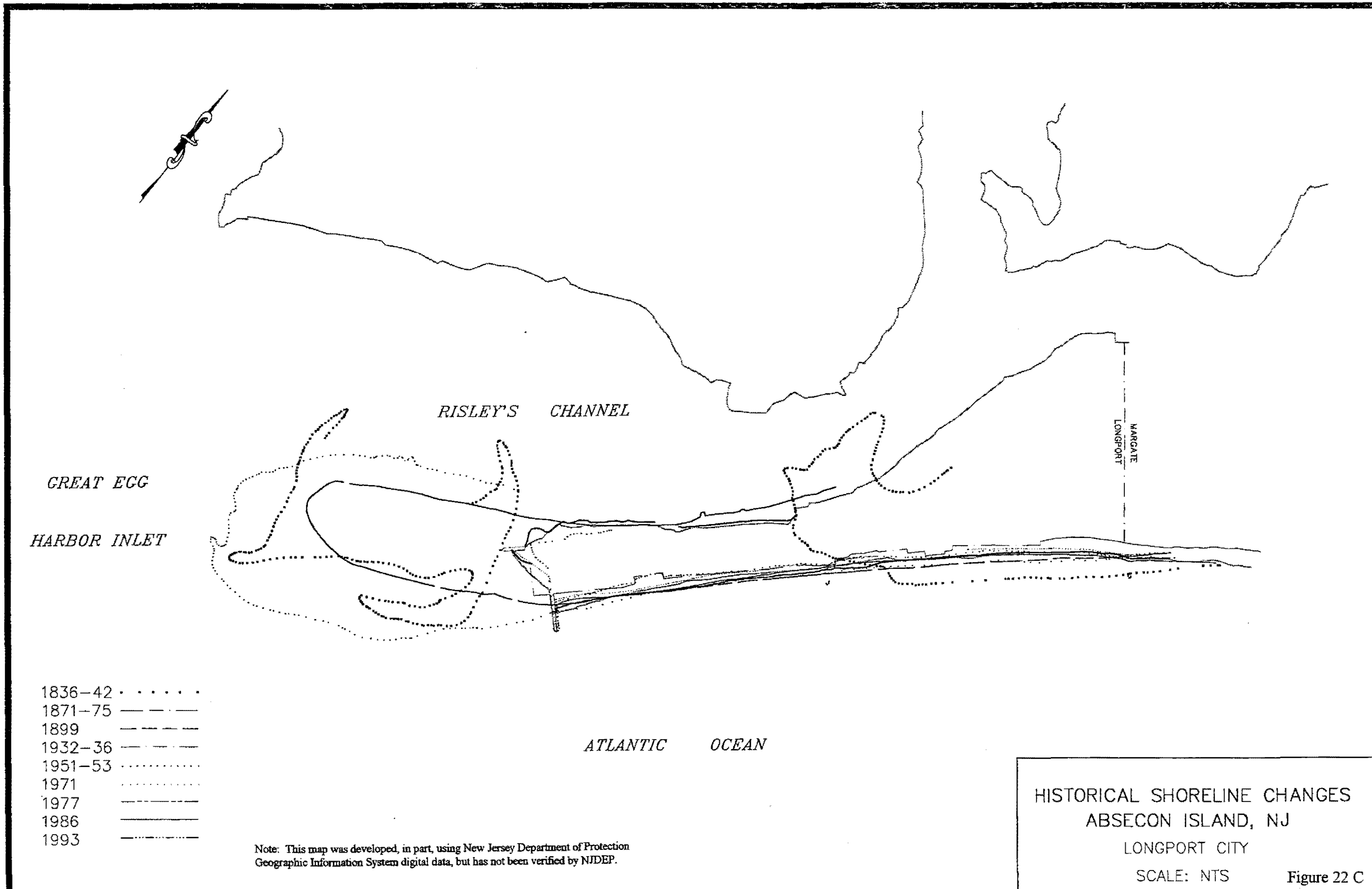

BEACH THOROFARE
MARGATE
LONGPORT
VENTNOR
MARGATE
ATLANTIC CITY
VENTNOR
ATLANTIC OCEAN
1836-42
1871-75
1899
1932-36
1951-53
1971
1977
1986
1993
Note: This map was developed, in part, using New Jersey Department of Protection Geographic Information System digital data, but has not been verified by NJDEP.
HISTORICAL SHORELINE CHANGES
ABSECON ISLAND
VENTNOR CITY
MARGATE CITY
SCALE: NTS

Figure 22 B



Note: This map was developed, in part, using New Jersey Department of Protection Geographic Information System digital data, but has not been verified by NJDEP.

HISTORICAL SHORELINE CHANGES
ABSECON ISLAND, NJ
LONGPORT CITY
SCALE: NTS

Figure 22 C

229. The shoreline along Longport has fluctuated through time, although it appears to be more stable since 1977 (Figure 22C). Construction of the terminal groin in 1953 helped to stabilize the large oscillations in shoreline immediately adjacent to Great Egg Harbor Inlet. Presently, the narrowest section of beach in Longport is located in the vicinity of 26th to 30th Ave.; however, it appears that this area has been historically narrow in beach width. A brief comparison of survey data from 1965 to 1993 for LRP 90 shows some erosion along the beach profile between July 1965 and November 1988 (although this may be accounted for by seasonal differences), and notable accretion from 1988 through 1993 (in addition to the 1990 beach fill material).

230. History of Beach Fills. The analysis of beach profile and aerial photographic data for Absecon Island is complicated by a number of activities, the most important being beachfill placement. Table 15 presented a history of beach fills for Absecon Island. Beach nourishments and other coastal construction activities have affected the otherwise normal evolution and response of the study area shorelines to natural physical factors such as waves and tidal currents. In order to estimate the probable "no-action" shoreline behavior, it is necessary to adjust the observed historic shoreline changes to account for the changes attributable to the beach fills.

231. EXISTING SHORELINE CONDITIONS. Various reaches along Absecon Island were evaluated to determine if the shoreline was stable, accreting, or eroding. Shoreline behavior was documented using aerial photography, beach profiles, shoreline change maps, and pertinent reports.

232. This analysis concluded that starting conditions for the base year of 2001 would best be represented by conditions documented in 1993 for the Absecon Inlet frontage of Atlantic City and for Ventnor Margate and Longport. Much of the Atlantic City oceanfront, however, which has required most of the beach nourishment placed since 1948, is considered likely to experience a progressive loss of beach width under the "no-action" scenario, although at an average long-term rate lower than that experienced immediately following previous placements. Table 16 reflects the average annual shoreline retreat rates which were adopted to reflect probable behavior of the Atlantic City ocean shoreline.

Table 16
Long Term Erosion Rates

Shoreline Locations	Erosion Rate (ft/yr)
Massachusetts to Pennsylvania Ave.	2.5
Pennsylvania to Martin Luther King Blvd.	2.5
Martin Luther King Blvd. to Arkansas Ave.	7.0
Arkansas to Brighton Ave.	7.0
Brighton to Albany Ave.	3.0

233. The remainder of Atlantic City, as well as Ventnor, Margate, and Longport, are projected to have no long-term erosion trend over the period of analysis for this study. Therefore, the conditions portrayed by the 1993 beach profiles were adopted to define "no-action" conditions for the beach recreation and storm erosion analyses.

234. Aerial photography and beach profile data from 1988, 1990 and 1993 were compared to determine if there have been significant changes in shoreline trends. The shoreline was examined primarily at each historical LRP profile line location. Given the natural short-term variability typical of beach profiles in this area, this analysis concluded that the rates provided in Table 16 are valid for the study area.

PROBLEM IDENTIFICATION

235. Water resource problems associated with the main study objectives are identified below. The problems which exist in the study area were identified during site visits, literature review, public and interagency coordination, surveys and aerial reconnaissance flights.

236. PROBLEM ANALYSIS. The problem categories are 1) shoreline erosion over the long term, 2) storm damage vulnerability with a high potential for storm-induced erosion, inundation and wave attack which is exacerbated by long term erosion and 3) shoreline stability along inlets.

237. The principal water resources problems identified along Absecon Island are progressive beach erosion due to long term shore processes, and the threat of storm damage. This reach of the New Jersey shoreline was one of the earliest to be developed. The Longport seawall was built in 1917 after the loss of the southernmost ten blocks of the community. Strides have been made in some areas to minimize losses associated with storm damage. Such advances include building code improvements, dune ordinances and building restrictions. Many portions of the developed coast will remain vulnerable however, due to the proximity of structures to the beach and the level of development.

238. LONG TERM SHORELINE EROSION. Progressive and constant erosion is evident in certain areas of the coastline. This erosion slowly narrows the protective beach width. Atlantic City's northern shoulder has long term erosion rates of between 2.5 and 7 feet per year.

239. It should be noted that simply because areas may have relatively stable or low background erosion rates does not preclude the need to fully address options for additional shore protection. Ventnor and Margate have relatively wide beaches in some areas but the dunes are small and discontinuous. Nor does a stable historic erosion rate mean that over the course of several years shoreline positions and elevations do not vary greatly. For example Longport, which has a relatively stable shoreline position due to its seawall, lost a great deal of beach elevation during the recent storms of 1991 and 1992. A lower beach elevation will allow larger waves to impact

the oceanfront. The beach elevation regained in subsequent years is presumably concurrent with a loss of sand in the northern beaches. Presently, much of the existing beachfront in Longport lacks an adequate dune system and the berm width is zero in front of the seawall.

240. FLOODING AND STORM DAMAGES. The principal source of economic damages identified along the Atlantic coast of New Jersey are storms. An accurate assessment of historic storm damages, delineated by causal mechanism, is difficult to develop for coastal storms. Along the study area, records of historic storm damages are poor except for the 1962 Northeaster, the coastal storm of 1984 and the December 1992 storm.

241. The years 1991-1992 brought three significant storms to the study area. A summary of historic storm damage information for the study area is presented in Table 17. Figures for some of the most recent storms have not been independently confirmed and do not necessarily represent the potential damages that could be prevented by a Federal shore protection project. Additionally, damages which qualify for post-storm FEMA assistance do not completely capture losses due to the storm.

TABLE 17

HISTORIC STORM DAMAGE DATA

DATE	DAMAGES	NOTES
9/1889	$50,000 (1889 $)	Heinz Pier, Atlantic City
10/1896	$33,000 (1896 $)	Atlantic City
9/38	$70,000 (1938 $)	Brigantine to Atlantic City
9/44	$5,000,000 (1944 $) $1,000,000 (1944 $)	Atlantic City; 62% attributable to wave damage. Ventnor, Margate, Longport
11/50	$564,000 (1950 $) $100,000 (1950 $)	Absecon Island Longport
3/62	$21,634,700 (1962 $)	Absecon Island; 10% attributable to wave action
3/84	$1,450,325 (1984 $)	Atlantic County
10/91	$13,000,000	Atlantic County (initial amount claimed by County)
1/92	$2,650,000	Absecon Island (NJDEP estimate to repair beaches only)
12/92	$1,183,854 $ 259,405 $ 437,070 $ 125,199 $2,600,000	Atlantic City Ventnor Margate Longport Atlantic County (FEMA qualified damages)

242. SHORELINE STABILITY ALONG INLETS. Shorelines in the vicinity of inlets are particularly difficult to predict yet their equilibrium is easy to disturb. Inlet channels which separate New Jersey's offset barrier islands typically hug the southern shoreline. Coupled with extensive development, these inlet frontages are subject to erosional pressure exerted by the location of the channel and waves entering the inlet from the northeast. Absecon Inlet frontage has been devoid of a beach since the stabilization of the inlet in the 1940's and 1950's.

243. Local reversals in the littoral transport are dominated by the tidal influence at the inlet, and the extent and location of shoals. This can be seen at the northern shoulder of Atlantic City. An example of the emphemoral nature of sandy beaches at an inlet is the erosion of the fillet at the southern end of Longport. In 1993, the configuration reverted to a condition which existed in the

1970's. In response, NJDEP placed a rock revetment at the bulkhead to prevent continued rapid erosion. Shortly thereafter, the beach returned.

244. PROBLEM IDENTIFICATION BY AREA. The study area has been subdivided into two distinct areas. Problems specific to each area are listed as follows.

245. Absecon Inlet Frontage - Atlantic City. The northeast facing orientation of Atlantic City's inlet frontage increases its vulnerability to storm damage. Also adding to its exposure is the lack of protective beach. When the Maine Avenue groins were constructed in the 1930's and 1940's, the shoreline was stabilized although the beach disappeared (see figure 23). The Absecon Inlet Federal Navigation Project completed in 1957 located the channel in its present location which can be discerned from Figure 24. Since that time, relocation of the inlet channel to the northeast has been considered on numerous occasions in an effort to reduce erosional pressure on the inlet frontage. The damage to boardwalk, roads, bulkheads and buildings during the winter storms of 1991-1992 reiterate the need to review shore protection ideas in the inlet.

246. Plans will be formulated which will address the damage mechanisms along the inlet frontage.

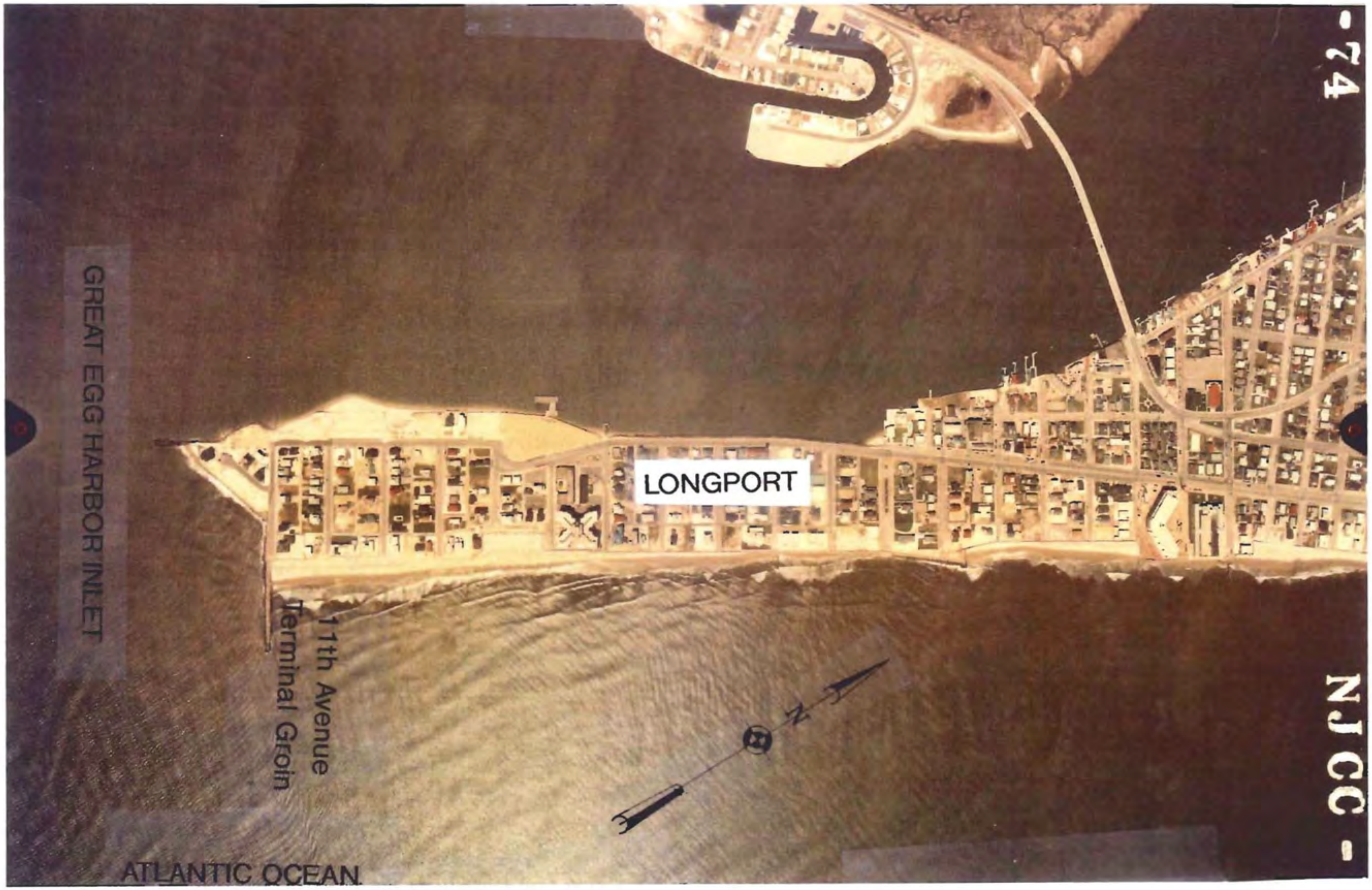
Figure 23

Absecon Inlet, NJ
South Side (Atlantic City)
Looking N-NW
19 December 1992

Figure 24

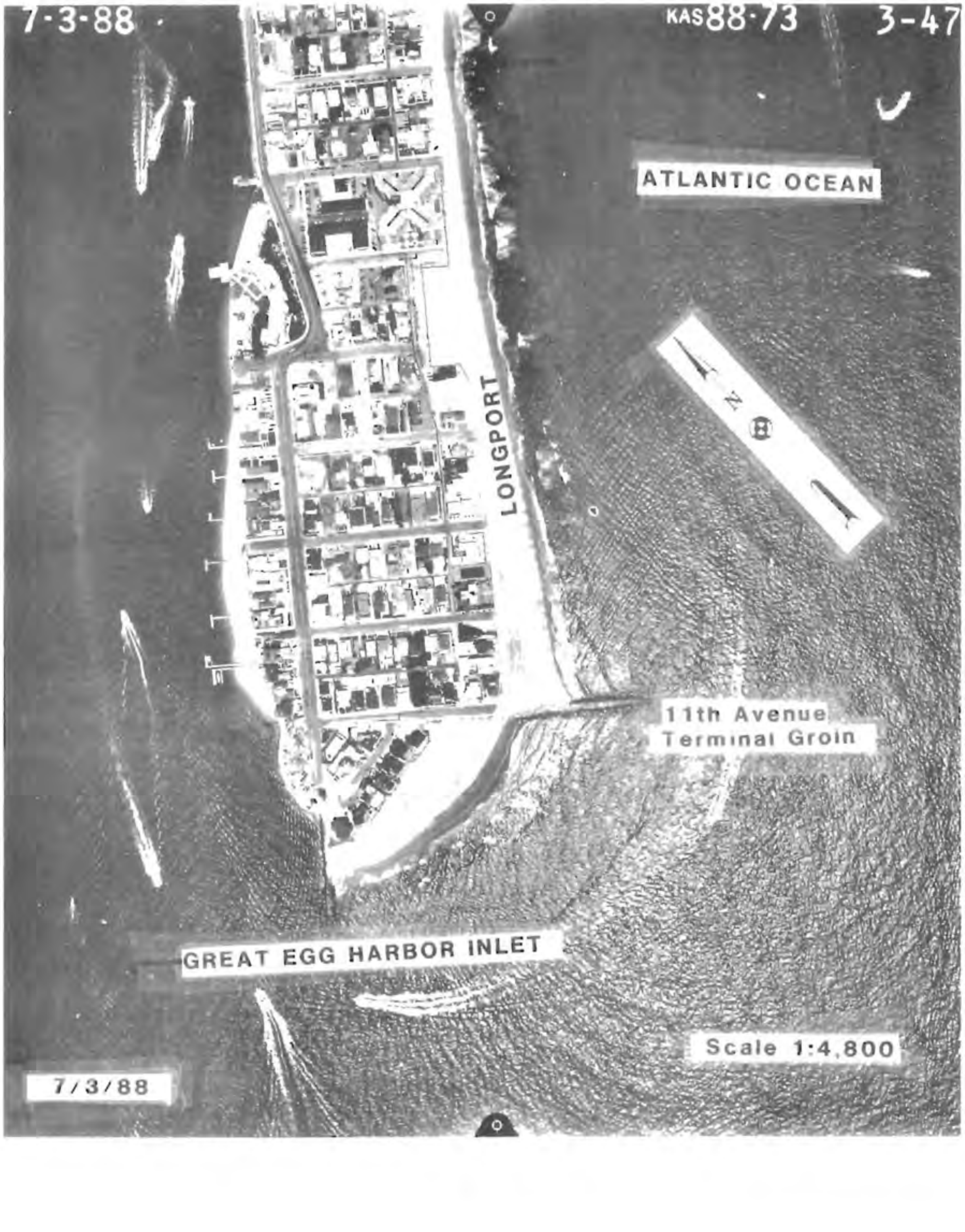
BRIGANTINE
ATLANTIC CITY
Maine Ave. Groins
ABSECON INLET
N
Oriental Ave.
Jetty
3/31/91
Scale 1:9,600

Figure 25



LONGPORT
GREAT EGG HARBOR INLET
11th Avenue
Terminal Groin
ATLANTIC OCEAN
N
-74
NJ CC -

Figure 26


7-3-88
KAS88-73
3-47
ATLANTIC OCEAN
N
LONGPORT
11th Avenue
Terminal Groin
GREAT EGG HARBOR INLET
Scale 1:4,800
7/3/88

247. Absecon Island Oceanfront. Of all the New Jersey barrier islands, Absecon Island historically suffers the greatest damage during coastal storms. As shown earlier in Table 15, Atlantic City has received several large beachfills since at least 1936 in an effort to maintain a beach along the northern end. A series of groins is in place in an attempt to stabilize the shoreline, especially in the area of Martin Luther King Blvd. where the shoreline geometry begines to change.

248. To the south of Atlantic City, the communities of Ventnor and Margate have very gently sloping, low elevation beaches with berm widths of approximately 50 to 150 ft. The low elevation became quite evident during the recent storms when flooding from the ocean side occurred despite the bulkheads. The majority of residential structures on Absecon Island are older homes built on slab foundations. This type of foundation is known to be less resistant to the damaging forces of major storm events.

249. The Borough of Longport is a narrow barrier island community poised precariously in Great Egg Harbor Inlet as seen in Figures 25 and 26. These figures also show how changes in beach width can occur. Note the cul-de-sac and location of homes at the southernmost end. Presently, subaerial beach is virtually nonexistent in many sections of the borough, nor are there any dunes. Protection is in the form of a curved face concrete seawall and timber bulkhead. A portion of the bulkhead failed during the storm of 4 January 1992 with subsequent damage to property in the vicinity of 32nd Street. Although massive, the concrete seawall has sufferred failure in the past due to undermining.

WITHOUT PROJECT CONDITIONS

250. The without project condition for this study made certain assumptions. The assumptions that follow were used in determining the future condition of the study area for the fifty year period following the base year which is 2001.

1) Long term erosion will continue with no action by local concerns to correct or reduce the erosion until the erosion reaches a fixed point. That point is usually a bulkhead or other shore protection structure.

2) Replacement of damaged structures is assumed to be in kind for both buildings and shore protection structures.

WITHOUT PROJECT HYDRAULIC ANALYSIS

251. STORM EROSION, INUNDATION AND WAVE ATTACK ANALYSES. Storm erosion, inundation and wave attack analyses were conducted for the Absecon Island oceanfront and inlet shorelines to determine the potential for erosion caused by waves and elevated water levels which accompany storms. Storm-induced erosion and coastal flooding is first evaluated for the without project or "no-action" condition, which is a projection of existing conditions in the base year of 2001. Similar analyses will then be conducted using selected alternatives for the with project conditions.

252. Factors Influencing Storm Effects. A brief summary of the mechanisms which result in beach and community erosion and inundation from coastal storms is provided in this section. Although wind, storm track, and precipitation are the primary meteorological factors affecting the damage potential of coastal storms, the major causes of damage and loss of life are storm surge, storm duration, and wave action.

253. Under storm conditions, there is typically a net increase in the ocean water level which is superimposed on the normal astronomic tide height fluctuations. The increase in water level caused by the storm is referred to as "storm surge." The effect of storm surge on the coast depends on the interaction between the normal astronomic tide and storm-produced water level rise. For example, if the time of normal high tide coincides with the maximum surge, the overall effect will be greater. If the surge occurs at low or falling tide, the impact will likely be lessened. The term "stage" as applied in this analysis pertains to the total water elevation, including both tide and storm surge components, relative to a reference datum (NGVD, used herein). The term "surge" is defined as the difference between the observed stage and the stage that is predicted to occur due to normal tidal forces, and is thus a good indicator of the magnitude of storm intensity. Slowly moving "northeasters" may continue to build a surge that lasts through several high tides. Such a condition occurred during the devastating March 1962 storm which lasted for five high tides.

254. In addition to storm surge, a rise in water level in the near shore can occur due to wave setup. Although short period surface waves are responsible for minimal mass transport in the direction of wave propagation in open water, they cause significant transport near shore upon breaking. Water propelled landward due to breaking waves occurs rather rapidly, but water returned seaward under the influence of gravity is slower. This difference in transport rates in the onshore and offshore directions results in a pileup of water near shore referred to as wave setup. Wave setup was computed and included in this storm analysis for Absecon Island.

255. There is typically also an increase in absolute wave height and wave steepness (the ratio of wave height to wave length). When these factors combine under storm conditions, the higher, steeper waves and elevated ocean stage cause a seaward transport of material from the beach face. The net movement of material is from the foreshore seaward toward the surf zone. This offshore transport creates a wider, flatter nearshore zone over which the incident waves break and dissipate energy.

256. Lastly, coastal structures can be exposed to the direct impact of waves and high velocity runup in addition to stillwater flooding. This phenomenon will be considered wave attack for the purpose of this analysis. Reducing wave attack with a proposed project such as a beach fill would reduce the severity of coastal storm damage and also improve the utility of bulkheads and seawalls during the storm.

257. Wave zones are the regions in which at least a 3 foot wave or a velocity flow that overtops the profile crest by 3 feet can be expected to exist. These zones are the areas in which greater structural damages are expected to occur. The remaining zones are susceptible to flooding by overtopping and waves less than the minimum of 3 feet. Total water level information for the study area was compiled, and the values used as input to the economic model which ultimately computes damages associated with all three storm related damage mechanisms.

258. MODELING STORM-INDUCED EROSION. Analyses of storm-related erosion for coastal sites require either a long period of record over which the important storm parameters as well as the resultant storm erosion are quantified, or a model which is capable of realistically simulating erosion effects of a particular set of storm parameters acting on a given beach configuration. There are very few locations for which the necessary period of prototype information is available to perform an empirical analysis of storm-induced erosion. This is primarily due to the difficulty of directly measuring many important beach geometry and storm parameters, before, during, and immediately after a storm. Thus, a systematic evaluation of erosion under a range of possible starting conditions requires that a numerical model approach be adopted for the study area.

259. The USACE has developed, released and adopted the numerical storm-erosion model SBEACH (Storm induced BEAch CHange) for use in field offices (Rosati, et al., 1993). SBEACH is available via a user interface available for the personal computer, or through the Coastal Modeling System (CMS) (Cialone et al., 1992). Comprehensive descriptions of development, testing, and application of the model are contained in Reports 1 and 2 of the

SBEACH series (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990).

260. <u>Overview of SBEACH Methodology</u>. SBEACH Version 3.0 was used in this analysis. SBEACH is a geomorphic-based two-dimensional model which simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels (Rosati, et al. 1993). SBEACH has significant capabilities that make it useful for quantitative and qualitative investigation of short-term, beach profile response to storms. However, since SBEACH is based on cross-shore processes, there are shortcomings when used in areas having significant longshore transport.

261. Input parameters include varying water levels as produced by storm surge and tide, varying wave heights and periods, and grain size in the fine-to-medium sand range. The initial beach profile can be input as either an idealized dune and berm configuration or as a surveyed total profile configuration. SBEACH allows for variable cross-shore grid spacing, simulated water-level setup due to wind, advanced procedures for calculating the wave breaking index and breaker decay, and provides an estimation of dune overwash. Shoreward boundary conditions that may be specified include a vertical structure (that can fail due to either excessive scour or instability caused by wave action/water elevation) or a beach with a dune. Output results from SBEACH include calculated profiles, cross-shore parameters, a log for each SBEACH run, and a report file.

262. <u>SBEACH Calibration</u>. Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by an actual storm. Due to the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model should be calibrated using data from beach profiles surveyed before and after storms at the project coast or a similar coast. The calibration procedure involves iterative adjustments of controlling simulation parameters until agreement is obtained between measured and simulated profiles.

263. The best profile data set for calibration along the Absecon Island study area consisted of USACE profile surveys taken at Ocean City, NJ prior to and just after the December 1992 storm. Shoreline configuration, grain size, and coastal processes at Ocean City, NJ are similar to those for the Absecon Island study area, therefore, calibration using this well-documented pre- and post-storm data is considered sound. Additionally, a wave hindcast of the December 1992 storm (Andrews Miller, 1993) was prepared for the Philadelphia District, and water level data for the storm was recorded at the Atlantic City tide gage. Initial calibration simulations produced insufficient erosion when compared to the post-storm profile data. With CERC's assistance, minor modifications were made to the SBEACH program to allow for factors particular to the southern New Jersey coastline. Final calibration was satisfactorily completed and typical calibration plots are provided in Appendix A. Controlling simulation parameters determined for the Absecon Island study area are as follows:

$K = 2.5e\text{-}6\ m^4/N$
$EPS = 0.005 m^2/sec$
LAMM = 0.10
BMAX = 40 deg
$D_{50} = 0.24$ mm

where K is the empirical transport rate coefficient, EPS is the coefficient for the slope dependant term, LAMM is the transpot rate decay coefficient multiplier, BMAX is the maximum profile slope prior to avalanching, and D_{50} is the effective grain size.

264. Development of Input Data for Storm Erosion Modeling. Transects were selected representing the "average" shoreline, structure, backshore configuration, and upland development conditions for various reaches in the study area. Storm erosion and inundation were computed relative to both a designated baseline and reference line. The reference line lies 200 ft seaward of the baseline as shown in Figure 27. The erosion results presented later in this section are provided relative to the reference line.

Baseline and Reference Line

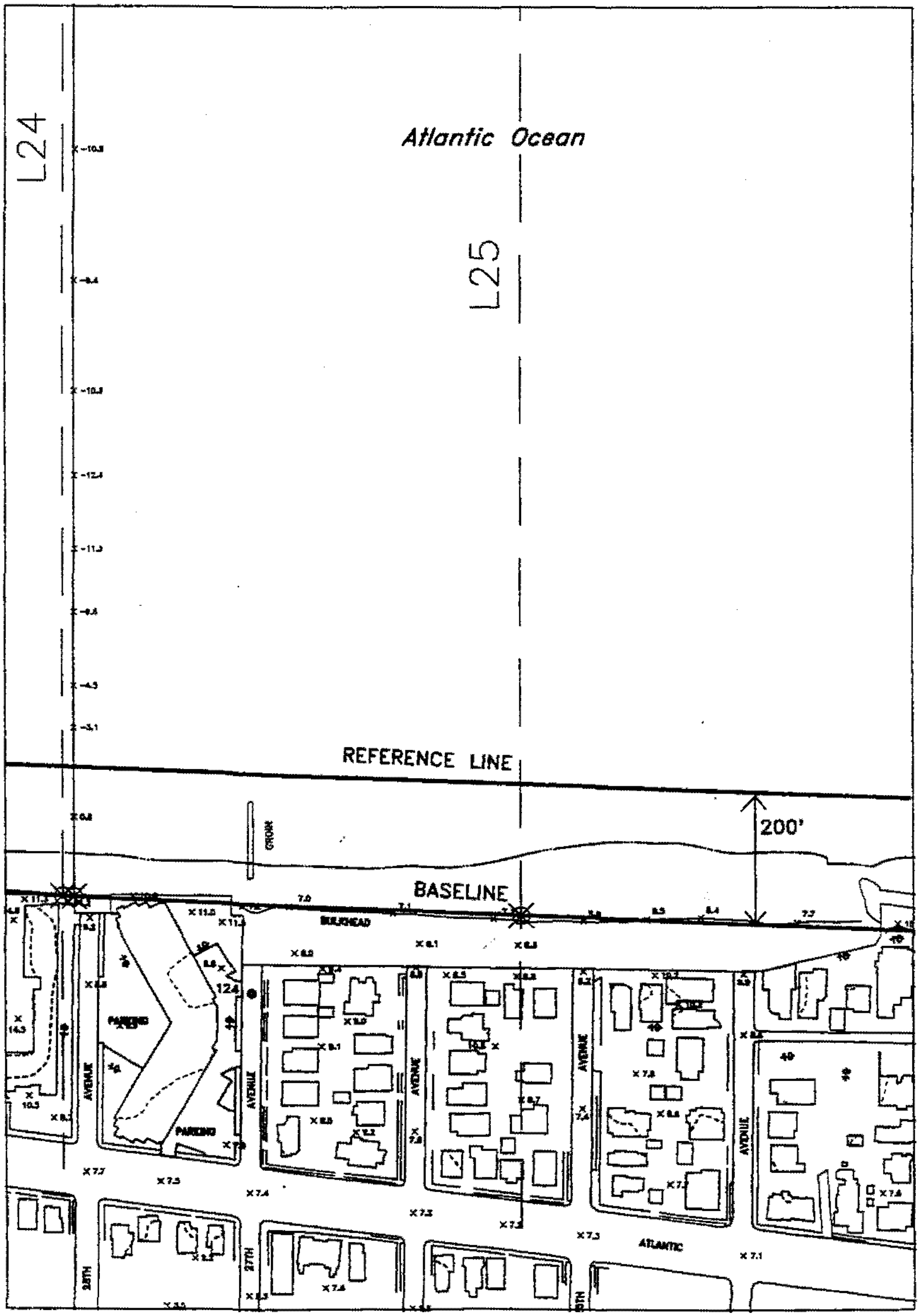


Figure 27

265. Input data was developed for all of Absecon Island with the exception of the shoreline along Absecon Inlet. This area was analyzed for inundation, erosion and wave attack separately using Shore Protection Manual methods since it does not have a profile appropriate for SBEACH's modeling capabilities. Additionally, the shoreline near the Oriental Ave. jetty and the Longport terminal groin were modelled with particular caution due to their proximity to Absecon and Great Egg Harbor Inlets, respectively.

266. Profile Data. Input beach profile data was developed from the onshore/offshore survey data collected for Absecon Island in August 1993. Six representative profiles were constructed to represent different sections of the Absecon Island shoreline as shown in Table 18. Each profile was extended landward approximately 1000 ft, using digital photogrammetry data, to allow for erosion and inundation computations into the community. Plots of the surveyed profile lines and the constructed representative lines used as input to SBEACH can be found in Appendix A.

Table 18
Average Profile Line Coverage for Absecon Island Oceanfront

Representative Profile Line Number	**Shoreline Represented by Profile Line**
1	Oriental Ave. to Vermont Ave.
2	Vermont Ave. to Massachusetts Ave.
3	Massachusetts Ave. to Arkansas Ave.
4	Arkansas Ave. to Jackson Ave.
5	Jackson Ave. to Portland Ave.; Richards Ave. to Kenyon Ave; Sumner Ave. to the Margate/Longport boundary.
6	Portland Ave. to Richards Ave.; Kenyon Ave. to Sumner Ave.; Longport/Margate boundary to 11th Ave.

267. Based on long-term erosion effects described in the Shoreline Conditions section , the developed input profiles represent the predicted beach in the base year. Because the Atlantic City shoreline between Massachusetts and Albany Ave. has exhibited a substantial long-term erosion trend, it was necessary to estimate the location of the erosion scarp at ten year intervals from the project base year assuming a continuation of the historic erosion pattern. The long-term erosion rates used for this task were presented in Table 16. SBEACH was then run for each of the eroded profiles in 10-year intervals from the base year through a 50-year project life period.

268. Model Parameters. Various model parameters required to run SBEACH are included in the input configuration file. The configuration file is separated into five sections: A - Model Setup; B - Waves/Water Elevation/Wind; C - Beach; D - Beach Fill; and E - Seawall/Revetment. Section A (Model Setup) deals with the initial and measured profiles, grid arrangement, output parameters, and calibration parameters. Section B facilitates entry of information about waves, water elevations, and winds. Section C allows entry of basic information related to beach profile data, and Section D allows for definition of a beach fill placed on the initial profile. An example configuration file is provided in Appendix A.

269. In Section E of the configuration file, the location and failure criteria for a seawall or revetment can be entered. Unlike many other storm erosion models, SBEACH can account for the presence of a vertical structure such as a seawall or bulkhead. The majority of Absecon Island, especially Ventnor, Margate, and Longport, is fronted with a nearly continuous line of some type of bulkhead or seawall. These structures were accounted for by inputing their locations along the profile along with appropriate failure criteria by waves, water levels, and profile scour. In Atlantic City, the concrete footings of the large buildings such as the casinos were treated in the model as unfailable seawalls. The northernmost and southernmost sections of Atlantic City have intermittent private bulkheads which were considered to not represent "average" conditions for those areas.

270. Water Elevation. The water level is the most important or first-order forcing parameter controlling storm-induced beach profile change, normally exerting greater control over profile change during storms than either waves or wind. Water level consists of contributions from the tide, storm surge, wave- and wind-induced setup, and wave runup; the latter three are computed within SBEACH. Input data in this case is tide and storm surge data. The combined time series of tide and surge is referred to as the hydrograph of total water level. The shape of the hydrograph is characterized by its duration (time when erosive wave conditions and higher than normal water elevation occur) and by its peak elevation.

271. Water level input data files for representativ 5-, 10-, 20-, 50-, 100-, 200-, and 500-yr events were developed for Absecon Island as part of the wave hindcast study conducted by OCTI. The Gumbel distribution (Fisher-Tippett Type I) was used. Extrapolation to higher recurrence intervals is more uncertain and it is generally recognized that this should not be extended to recurrence intervals greater than 2-3 times the length of the period over which the population is drawn . Therefore, extrapolation to the 200 and 500-yr events will contain the most uncertainty.

272. Wave Height, Period, and Angle. Elevated water levels accompanying storms allow waves to attack portions of the profile that are out of equilibrium with wave action because the area of the beach is not normally inundated. Wave height and period are combined in an empirical equation within SBEACH to determine if the beach will erode or accrete for a time step. In beach erosion modeling, a storm is defined neither by the water level nor by the wave height or period alone, but by the combination of these parameters that produces offshore transport.

273. The SBEACH Version 3.0 allows for the input of random wave data, that is, waves with

variable height, period, and direction or angle. The storm wave data used in this analysis were generated in the OCTI wave hindcast described previously for the seven representative events. Storm wave heights, as well as water levels, were developed by rescaling hindcasted actual storm time series.

274. Storm Parameters. A variety of data sources were used to characterize the storms used in this analysis. The twenty highest ocean stages recorded at the Atlantic City tide gage between 1912 and 1994 were listed in Table 12. For each stage, additional information on the storm type causing the water surface elevation and if possible the actual storm surge hydrograph were obtained. Of the 20 highest events, 12 are northeasters and 8 are hurricanes. The duration of hurricanes along the New Jersey shore is generally less than 24 hours, while the average duration of northeasters is on the order of 40 hours, and in some cases (e.g., 5-7 March 1962) considerably longer. Though actual storm surge hydrographs are not available for all storm events, it was assumed that all hurricanes exhibit similar characteristics to one another. Northeasters demonstrate similar features; however, durations may vary significantly from storm to storm.

275. Storm Erosion Simulations. The SBEACH model was applied to predict storm-induced erosion for the Absecon Island study area. All representative storm events were run against the six average pre-storm profiles. Model output for each simulation includes a post-storm profile plot, and several report and post-processing files. Simulation results from each particular combination of profile geometry and storm characteristics yield predicted profile retreat at three selected elevation contours. In this analysis, profile retreat for any given storm event was measured landward from the proposed project construction base line to the location of the top of the erosion scarp on the beach face. Typical plots of input pre-storm profiles and the resultant post-storm profiles based on SBEACH predicted retreat are provided in Appendix A.

276. A large portion of the Absecon Island coastline is structured with some type of bulkhead or seawall. Additionally, geotubes have been placed along portions of Atlantic City as shoreline protection structures. In order for storm erosion to affect the community, the geotube, bulkhead or seawall must fail. The SBEACH simulates failure through a number of mechanisms including storm induced scour at the toe of the structure, direct wave attack, or inundation. Failure criteria for protective structures were developed based on a synthesis of available data, including design and construction information, existing condition typical cross-sections, and field inspection of the structures. The appropriate failure criteria were input to the SBEACH configuration file for each profile. Model simulations typically resulted in failure of the bulkheads by excessive water elevation at the 100, 200, and 500-year storms. The SBEACH does not have the capability to accurately model the geotube structures therefore other analysis techniques and engineering judgement were used to account for geotube failure. For the without project condition, these structures fail during the 50 year storm.

277. Analysis of Erosion Model Results. Two approaches can be taken to estimate storm-induced beach erosion: the "design-storm" and the "storm-ensemble" approach. For the storm-ensemble approach, erosion rates are calculated from a large number of historical storms and then ranked statistically to yield an erosion-frequency curve. In the design-storm approach, the

modeled storm is either a hypothetical or historical event that produces a specific storm surge hydrograph and wave condition of the desired frequency. The design-storm approach was used in the storm erosion and inundation analyses for Absecon Island. Volumetric erosion into the community per unit length of shoreline can subsequently be computed from the pre- and post-storm profiles.

278. Results of the without project storm erosion analysis are presented in Table 19. The predicted shoreline erosion positions are reported relative to the reference line. For those areas with protective structures, zero erosion into the community is reported until structure failure occurs. These erosion values were offset appropriately for various areas and were used as input to the economic model which ultimately computes storm damages associated with storm-related erosion.

Table 19
Storm Erosion Analysis
Predicted Without Project Shoreline Erosion Positions

Representative Profile	Erosion Position (ft)[1/]						
	5 yr	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**200 yr**	**500 yr**
1[2/]	500	505	510	530	550	660	700
2[3/]	0	0	0	455	475	500	520
3[4/]	145	155	160	170	175	185	210
4[5/]	240	250	290	320	360	380	400
5[6/]	90	95	100	110	310	320	325
6[6/]	190	195	198	198	400	415	425

Note:
1/ Distances reported are landward erosion limits of the beach profile landward of the Reference Line.
2/ Landward edge of boardwalk located at 720 ft.
3/ Erosion for portions with geotube truncated at 0; landward edge of boardwalk at 360 ft.
4/ Unfailable seawall located at 254 ft.
5/ Landward edge of boardwalk at 295 ft.
6/ Bulkhead located at 200 ft.

279. STORM INUNDATION EVALUATION. The project area is subject to inundation from several sources including ocean waves overtopping the beach and/or protective structures as well as flooding from the back bay. The inundation can be analyzed as two separate categories: 1) Static flooding due to superelevation of the water surfaces surrounding the project area and 2) wave attack, the direct impact of waves and high energy runup on coastal structures.

280. In order to quantify the effects from flooding and wave attack, all inundation events are based on the ocean stage frequency discussed in an earlier section. Because the wave-effect contribution to total water level at the shoreline can be significant, wave setup is estimated and added to the stage-frequency curve for determination of inundation effects. Higher water elevations associated with wave runup (unique from wave setup) were also estimated at all vertical structures and profile crest locations.

281. Setup. Effects due to wave setup are considered in the inundation-stage frequency curve. In this analysis, setup was estimated using the Wave Information Study (WIS) Report 30, Shore Protection Manual techniques, and the Automated Coastal Engineering System's (ACES) routine for "Extremal Significant Wave Height Analysis." Table 20 presents the adopted total inundation stage-frequency data at selected recurrence intervals.

Table 20
Inundation Frequency
Stage Plus Wave Setup

Year Event	Annual Probability of Exceedence	Water Surface Elevation (ft, NGVD)
5	0.20	9.4
10	0.10	10.0
20	0.05	10.6
50	0.02	11.8
100	0.01	12.9
200	0.005	13.9
500	0.002	15.5

282. Runup. Wave runup was calculated using Shore Protection Manual techniques and the ACES routine for "Wave Runup and Overtopping and Impermeable Structures" and "Irregular Wave Runup on Beaches." Runup was evaluated for both vertical bulkhead structures and the curved concrete seawall, as well as irregular runup on beaches and dunes. Based on the Federal Emergency Management Agency (FEMA) methodology used in the inundation analysis, runup was evaluated to determine if it was greater than or less than the 3 ft above crest elevation criteria. Estimates of wave runup at each storm frequency were then included in the inundation analysis.

283. Flooding. The project area is subject to flooding from back bay and adjacent waterways as well as direct ocean inundation. This elevated stage flooding is referred to as back bay stillwater

flooding. Construction of a shore protection feature will not significantly reduce the flood depths caused by the elevated stage of the back bay waters. This flooding is accounted for by subtracting the residual damages due to back bay flooding from the damages caused by ocean front inundation.

284. WAVE ATTACK. Coastal structures can be exposed to forces in addition to stillwater flooding which are attributed to the direct impact of waves and high velocity runup and overtopping. These combined phenomena will be considered the wave attack for the purpose of this analysis. The inland wave attack and inundation methodology used in this evaluation is based upon FEMA guidelines for coastal flooding analysis. The procedure divides possible storm conditions into four cases briefly described below:

Case 1 (shown in Figure 28): Entire storm-generated profile is inundated.

Case 2 (shown in Figure 29): The top of the dune/profile crest is above the maximum water level, with wave runup greater than 3 feet above the dune crest elevation.

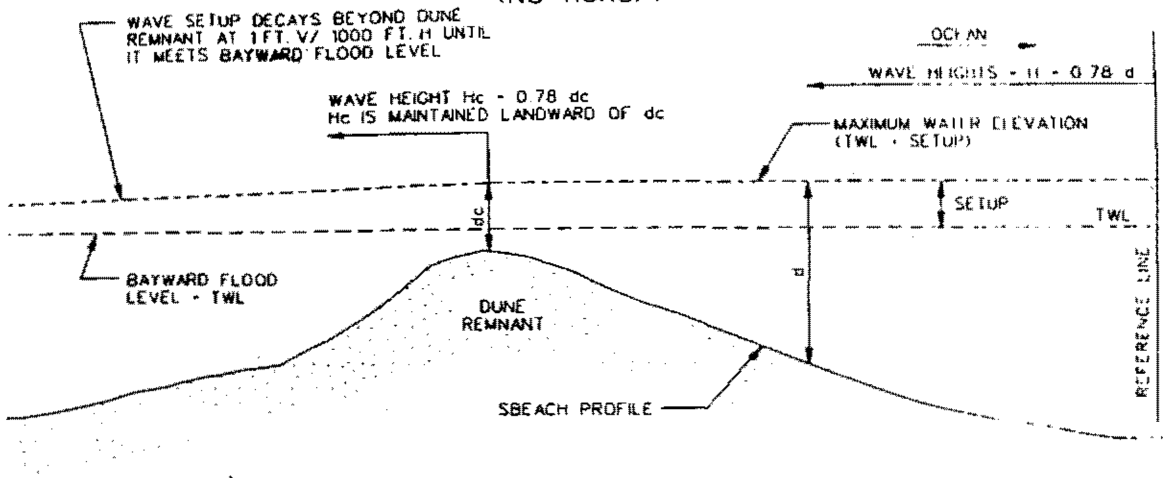
Case 3 (shown in Figure 30): The top of the dune/profile crest is above the maximum water level, with wave runup exceeding but less than 3 feet above the dune crest elevation.

Case 4 (shown in Figure 31): The wave runup does not overtop the dune, the wave zone is limited to seaward of the dune.

285. Criteria for Damage. To evaluate the added potential for structural damage, the boundaries of the wave attack must be delineated, and the critical damage wave height identified. Return periods of 5, 10, 20, 50, 100, 200, and 500 years associated with the inundation-frequency curve were evaluated. The analysis estimates the location of a wave attack line and the associated zones of high energy stages. The wave attack line is the most landward position of the swash zone where the force due to waves exceeds the force required to damage typical coastal structures. Any structure located landward of this line is subject to the equivalent of stillwater flooding because the wave heights are not sufficient to cause the accelerated damages incurred seaward of the wave attack line.

286. A 3.0-ft wave height is assumed as the minimum wave that would cause damage to typical structures. This is based on the Corps of Engineers report "Guidelines for Identifying Coastal High Hazard Zones", and the FEMA's report "Guidelines and Specifications for Wave Elevation Determination and V-Zone Mapping", which both report a 3.0-ft wave height as the critical wave for damage.

CASE I
ENTIRE STORM-GENERATED PROFILE IS INUNDATED
(NO RUNUP)



dc = CONTROLLING DEPTH (MINIMUM DEPTH) OVER DUNE REMNANT

d = ANY DEPTH BETWEEN REFERENCE LINE AND dc

Hc = 0.78 dc; THIS WAVE HEIGHT IS MAINTAINED LANDWARD OF dc

H = 0.78 d, THIS IS THE HEIGHT OF WAVES BETWEEN THE REFERENCE LINE AND dc AND VARIES IN ACCORDANCE WITH VALUES OF d

WAVE ENVELOPE ABOVE COMBINED WATER LEVEL IS ESTABLISHED ON THE BASIS OF ADDING 0.7 H (OR 0.7 Hc AT AND LANDWARD OF dc) TO THE COMBINED WATER LEVEL

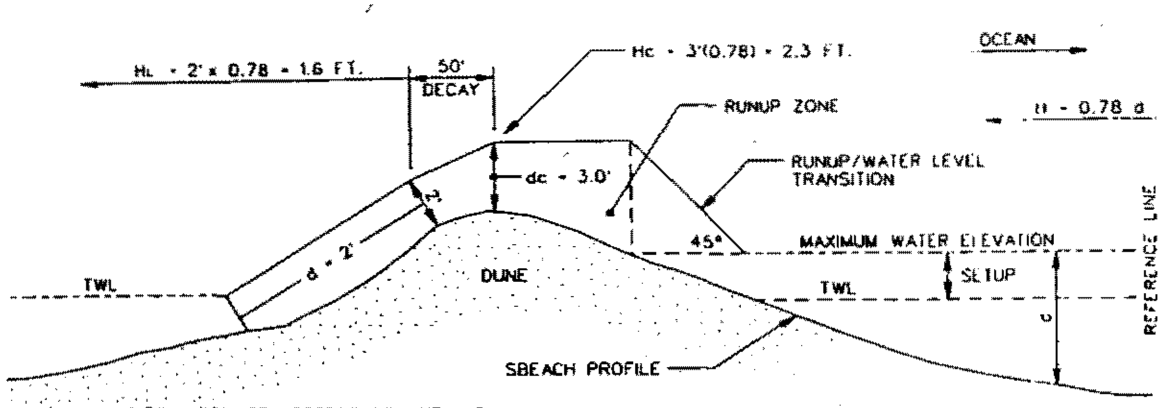
TWL = PEAK ELEVATION OF STORM SURGE PLUS ASTRONOMICAL TIDE

WAVE SETUP = WAVE SETUP GENERATED BY SBEACH MODEL

MAXIMUM WATER ELEVATION = TWL + WAVE SETUP

Figure 28

CASE II
TOP OF DUNE ABOVE COMBINED WATER LEVEL
WITH WAVE RUNUP ≥ 3.0 FT. ABOVE DUNE CREST ELEVATION



H = 0.78 d BETWEEN REFERENCE LINE AND dc

Hc = 0.78 dc AT dc

HL = LANDWARD WAVE HEIGHT = 1.6 FT. LANDWARD OF POINT WHERE RUNUP DECAYS TO A DEPTH OF 2 FT. (50' FROM dc = 3.0)

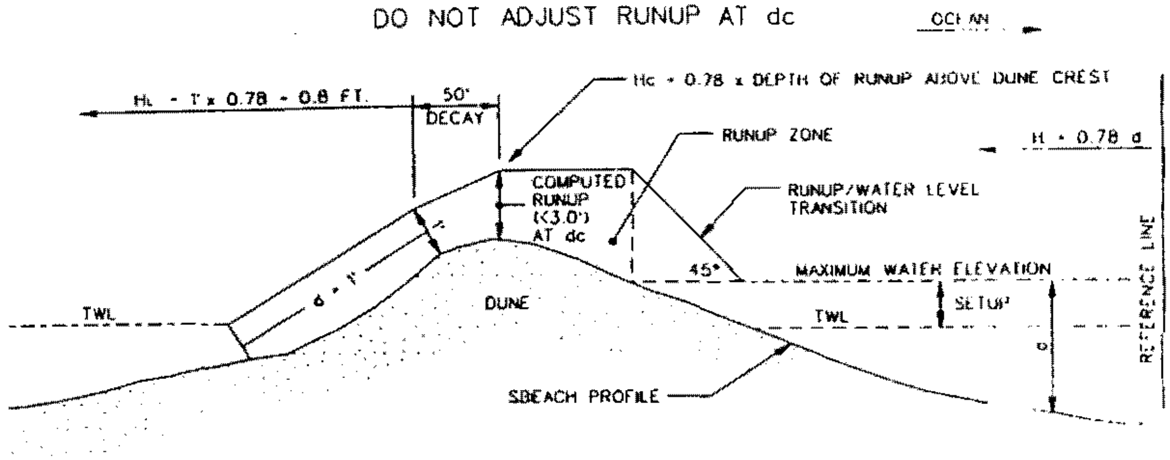
WAVE ENVELOPE (AS IN CASE I), i.e., 0.7 (H, Hc OR HL) ABOVE COMBINED WATER LEVEL OR THE WATER LEVEL ELEVATIONS AT AND LANDWARD OF dc

TWL, WAVE SETUP ARE SAME AS IN CASE I

MAXIMUM WAVE ELEVATION OVER DUNE INCLUDES WAVE RUNUP

Figure 29

CASE III
TOP OF DUNE ABOVE COMBINED WATER LEVEL
WAVE RUNUP < 3.0 FT. ABOVE DUNE CREST
DO NOT ADJUST RUNUP AT dc



H = 0.78 d BETWEEN REFERENCE LINE AND dc (COMPUTED DEPTH OF RUNUP OVER DUNE CREST)

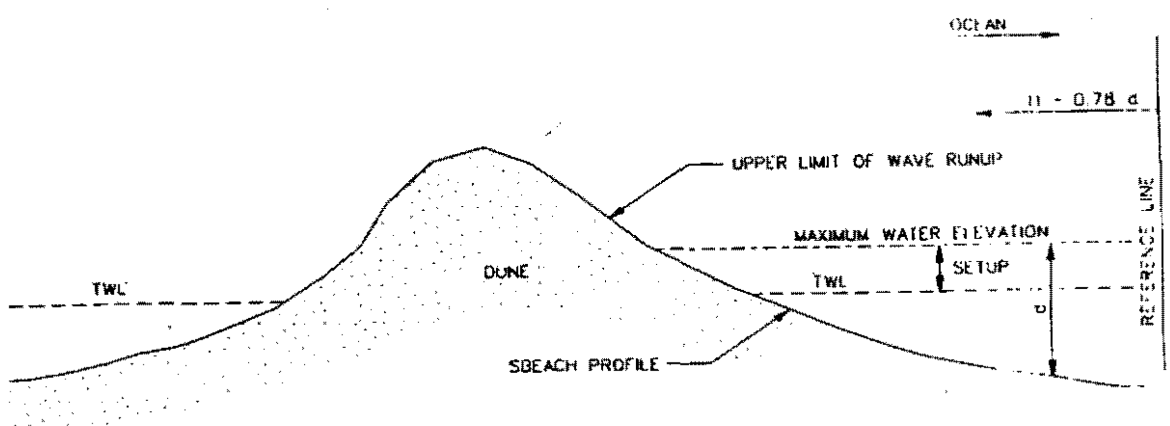
Hc = 0.78 x DEPTH OF RUNUP OVER DUNE CREST

HL = LANDWARD WAVE HEIGHT = 0.8 FT. LANDWARD OF POINT WHERE RUNUP DECAYS TO A DEPTH OF 1 FT (50' FROM dc)

WAVE ENVELOPE, TWL, WAVE SETUP AND MAXIMUM WATER ELEVATION ARE SAME AS IN CASE II

Figure 30

CASE IV
WAVE RUNUP DOES NOT OVERTOP DUNE



H = 0.78 d BETWEEN REFERENCE LINE AND SEAWARD FACE OF DUNE

Figure 31

287. The bulkheads, revetments, and seawalls located in the project area reduce the direct impact from wave attack and erosion damage. For all but the most extreme events, failure of the protective structures is required for significant wave attack to occur. However, extreme waves on certain profiles can plunge over the fixed barriers and attack the adjacent structures causing significant damage. The recurrence intervals in which the protective structures will fail for each area were determined previously in conjunction with the erosion analysis.

288. WITHOUT PROJECT INUNDATION AND WAVE ATTACK RESULTS. Table21 provides an example of the computed inundation/wave profile for Atlantic City in the vicinity of Albany to Jackson Ave. Similar inundation profiles were computed for other reaches in the study area to determine the total water level along the beach profile and into the community. The effects of stage plus setup, wave amplitude, wave runup at structures or berm crest location were incorporated into the total water level. The total water level is the combination of the computed stage, the setup (which is a superelevation of the water surface at the shoreline caused by larger storm waves breaking offshore and piling up on the beachface), the amplitude of the maximum non-breaking wave that can exist within the region, and runup height above the estimated water level if waves are breaking on the beach face.

Table 21
Without Project Inundation/Wave Analysis - Typical Inundation and Wave Profile

INUNDATION PROFILE   DISTANCE FROM REFERENCE LINE AND TOTAL WATER LEVEL POINTS

Storm Event	Distance from Reference Line (ft)	Total Water Elevation (NGVD)
5 Year	0 190 362 433 483 1000	12.1 10.5 9.6 8.8 6.3 6.3
10 Year	0 190 362 433 483 1000	12.9 11.3 10.4 10.1 8.9 6.8
20 Year	0 190 390 433 483 1000	14.1 12.5 11.5 11.2 10.0 7.2
50 Year	0 190 390 433 483 1000	15.9 14.4 13.4 13.0 11.8 8.2
100 Year	0 190 433 483 533 1000	17.9 16.5 15.4 13.8 12.5 9.2
200 Year	0 190 433 483 533 1000	19.7 18.2 17.2 15.5 14.1 10.1
500 Year	0 160 433 483 533 1000	22.7 21.4 20.2 18.6 17.1 11.3

WAVE IMPACT ZONES - DISTANCE Landward from Reference Line (Feet)

5 Year: 270
10 Year: 280
20 Year: 320
50 Year: 415
100 Year: 490
200 Year: 680
500 Year: 900

WITHOUT PROJECT ECONOMIC ANALYSIS

289. The following section details the economic analysis performed to evaluate the damages for the without project conditions on Absecon Island. Damage categories evaluated include reduction in storm erosion and wave/inundation damages. The basic underlying assumptions include a discount rate of 7 5/8%, October 1995 price level, a 50 year project life, and a base year of 2001.

290. STRUCTURE INVENTORY AND REPLACEMENT COSTS. The study area was delineated into the following three reaches: (1.) the inlet area of Atlantic City, (2.) the oceanfront of Atlantic City, and (3.) Ventnor, Margate and Longport based on the physical setting, hydraulic and economic factors. All analyses were done on a reach by reach basis and used to calculate without project total damages. A database containing approximately 330 ocean block structures in Longport, 330 in Margate, 230 in Ventnor, 310 in Atlantic City on the oceanfront and 45 on the inlet frontage of Atlantic City was compiled. Each structure was specifically inventoried and mapped on aerial photography at a scale of 1"=50'. Information collected includes address, construction and quality type, number of stories, first floor elevations, ground elevations and foundation type. For multi-family residential and commercial structures the number of units and names of businesses were also gathered.

291. The assimilation of this data was enhanced by using aerial ortho-digital mapping and the geographic information system, MIPS (Micro Imaging Processing System). This information, along with quality and condition of a structure, was entered into the Marshall and Swift Residential and Commercial Software Estimators which calculates depreciated replacement cost value. Only the replacement cost value for the first two floors (vulnerable to storm damage) of high rise buildings and casinos were entered into the database and used to estimate damages. The associated content value of each structure was estimated to be 40% of the structural replacement cost.

292. The structure inventory consists of single family homes, multi-family dwellings such as apartment and condominium buildings, and commercial establishments such as hotel-casinos, multi-unit retail structures, arcades, malls and office and public buildings. Local officials, and redevelopment agencies have embarked upon substantial development plans for the Inlet area. Almost 200 townhouses have been constructed recently. Land acquisition and remediation has been conducted to commence construction of two mid-rise multi-unit complexes of similar construction to an existing multi-unit building (Ocean Terrace) in the area, and conceptual plans for a water park have been designed.

293. In Atlantic City, the inclusion of multi-unit commercial structures may result in higher equivalent annual damages than a database weighted with more residential structures. The database consists of over 30 structures classified as hotels/casinos, a shopping mall, and a convention center. The estimated total replacement cost for all structures is over 600 million dollars and contain 200 million dollars in content replacement cost. The average replacement cost for residential structures included in the database for Atlantic City Inlet, Atlantic City

Oceanfront, and Ventnor, Margate, Longport are $196,00, $248,000, and $294,000, respectively. The average replacement cost for commercial structures and contents (hotels/casinos; malls, etc.) included in the database for Atlantic City Inlet, Atlantic City Oceanfront, and Ventnor, Margate, Longport are $3.9, $2.9, and $1.8 million, respectively. The inventory of structures in each area extended approximately one block from the oceanfront or inlet frontage.

294. The communities of Ventnor, Margate, and Longport were evaluated as one unit due to their similarities. Land-use is primarily residential with relatively few commercial lots in proximity to the ocean. Most commercial activities are located in the resort city of Ventnor. Development is continuous along the oceanfront of Ventnor, Margate, and Longport. As shown in the table below, several hydraulic parameters or shoreline characteristics are also comparable.

Table 21A
Structure Characteristics for Ventnor, Margate and Longport

Characteristics	**Ventnor**	**Margate**	**Longport**
# of Structures/Mile	137	199	235
Type of Development	residential	residential	residential
Long Term Erosion Rate	0 ft/yr.	0 ft/yr.	0 ft/yr.
Direction of Littoral Transport	southwest	southwest	southwest
Orientation of Shoreline	northeast to southwest	northeast to southwest	northeast to southwest
Seawall/Bulkhead Fails	100 year event	100 year event	100 year event
Primary Damage Mechanism	wave-inundation	wave-inundation	wave-inundation

295. The study area was delineated into the following three reaches: (1.) the inlet area of Atlantic City, (2.) the oceanfront of Atlantic City, and (3.) Ventnor, Margate and Longport based on the physical setting, hydraulic and economic factors. All analyses were done on a reach by reach basis and used to calculate without project total damages.

296. STORM DAMAGES. Damages (for without and with project conditions) were calculated for seven frequency storm events (5, 10, 20, 50, 100, 200, and 500 year events) for erosion, wave and inundation damage to structures, infrastructure and improved property. The calculations were performed using COSTDAM. COSTDAM is a Fortran program originally written by the Wilmington District and updated for the Philadelphia District. COSTDAM reads an ASCII 'Control' file which contains the storm frequency parameters for each cell and an ASCII 'Structure' file which contains the database information of each structure as previously described. A sample of this structure file is provided in Table 22. COSTDAM checks if a structure has been damaged

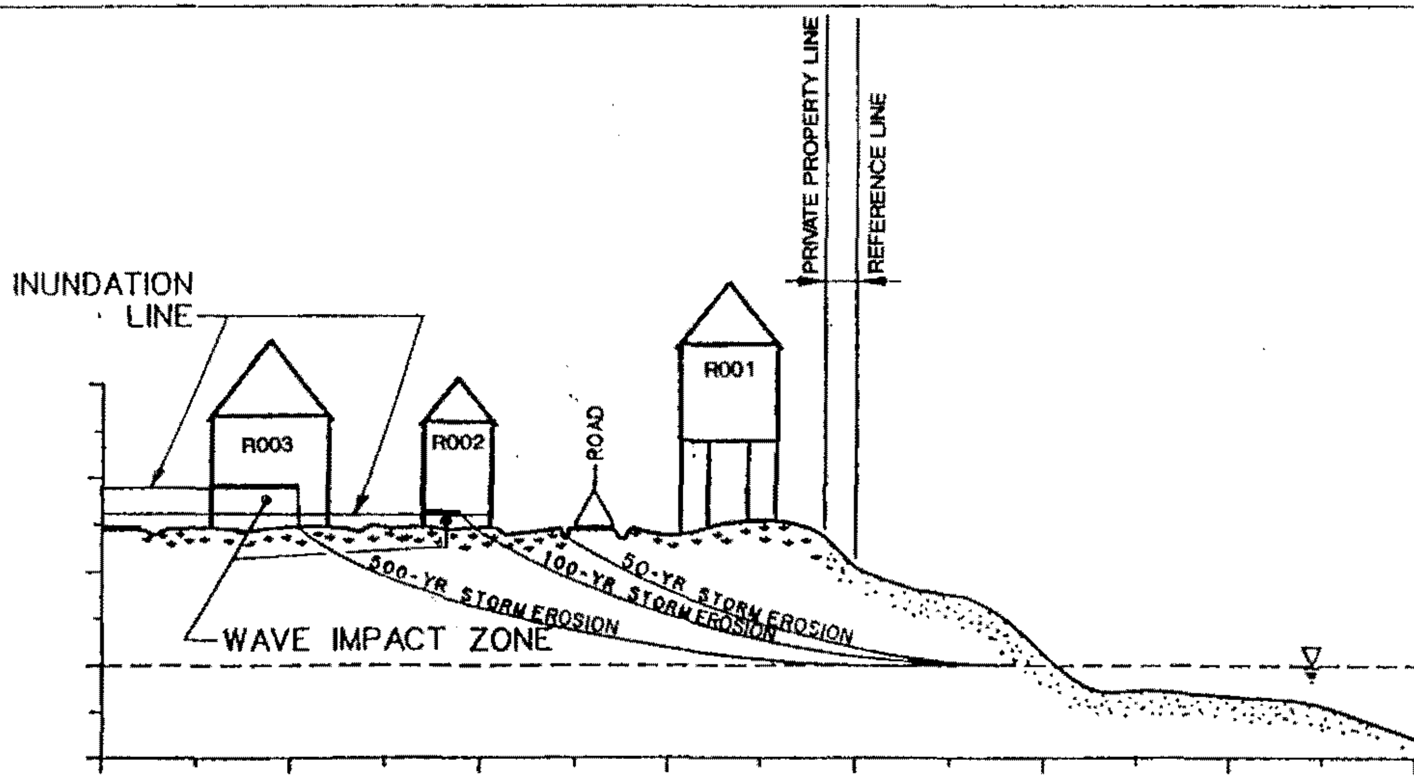
by wave attack, based on the relationship between a structure's first floor elevation and the total water elevation that sustains a wave. Then COSTDAM checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation based on FIA depth-damage curves adjusted for increased salt water damagibility. To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any given mechanism (wave, erosion, inundation) and drops the rest of the damages from the structure's total damages. (See Figure 32 for illustration.) Average annual damages are calculated for each reach.

TABLE 22
STRUCTURE FILE EXCERPT

V152230	271.3	289.2	10.9	4.0	221.	88.S03S04 1-1
V152231	309.6	332.7	10.5	7.0	290.	116.S07S08 1-1
V152232	370.0	389.3	10.4	3.2	293.	117.S03S04 1-1
V152233	416.1	436.7	10.4	3.1	188.	75.S03S04 1-1
M163000	418.8	436.8	9.7	3.9	237.	95.S03S04 1-1
M163001	368.1	386.3	12.4	2.5	250.	100.S03S04 1-1
M163002	307.9	331.4	10.3	0.3	266.	106.S07S08 1-1
M163003	256.3	280.9	10.6	2.7	298.	119.S07S08 1-1
M163004	218.9	235.9	10.4	3.1	273.	109.S03S04 1-1
M163005	212.2	225.2	10.4	2.7	256.	102.S03S04 1-1
M163006	264.5	281.7	10.8	3.6	322.	129.S07S08 1-1

Columns 1-3 contain the Cell ID (format-A3).
Columns 4-9 contain the Structure ID (format-A6).
Columns 10-19 are blank.
Columns 20-27 contain distance to front of structure (format-F8.1)
Columns 28-35 contain distance to middle of structure (format-F8.1)
Columns 36-40 contain the ground elevation (format-F5.1)
Columns 41-44 contain the distance between the first floor and the ground (format-F4.1)
Columns 45-53 contain the structure replacement cost value (format-F9.0)
Columns 54-62 contain content replacement cost value (format-F9.0)
Columns 63-65 contain the structure depth damage curve (format-A3)
Columns 66-68 contain the content depth damage curve (format-A3)
Columns 69-70 contain a code to make structure "active" (format-I2)
Columns 71-72 contain the damage category (format-I2)

Without Project Damage Mechanisms



CROSS-SECTION VIEW WITHOUT PROJECT

PERCENT DAMAGED						
HOUSE	50 YEAR STORM		100 YEAR STORM		500 YEAR STORM	
	EROSION	WAVE / INUN.	EROSION	WAVE / INUN.	EROSION	WAVE / INUN.
R001	100%	0	100%	0	100%	0
R002	0	1%	50%*	13%	100%	0
R003	0	1%	0	13%	57%*	28%

* TAKE SINGLE HIGHEST DAMAGE PERCENTAGE ONLY TO PREVENT DOUBLE COUNTING

Figure 32

297. EROSION DAMAGES. The distance between the reference (profile) line and the oceanfront and back walls were measured in AutoCAD using the georeferenced MIPS mapping of the study area. This technique reduces the amount of human error and photographic distortion relative to the technique used in the reconnaissance study. For the structure damage/failure analysis, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure's footprint if the structure is not on a pile foundation. If the structure is on piles, the land below the structure must have eroded through the footprint of the structure before total damage is claimed. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point.

298. For townhouse/rowhouse structures perpendicular to the ocean, each unit has unique ocean and back wall distances due to the local building ordinance which mandates that every unit have two hour firewalls. These walls should provide enough stability that townhouse units in a building can remain standing and be utilized after the unit(s) closer to the ocean is/are damaged. This has no bearing on townhouse units parallel to the ocean which would all have the same erosion point, because they are essentially equal distance from the reference line. Other multi-family structures, such as apartments and condominiums, will not have unique erosion points for each unit, because most of these structures were built before the local ordinance mandating firewalls was in place. Large high rise structures, such as apartment buildings, hotels and casinos, are not subjected to total erosion damage by undermining because of their deep piled foundations.

299. In addition to erosion damage to structures, damage to the land the structures are on (hence forth called improved property) was calculated. The improved property value was determined by comparing market value of the improved property to the cost of filling in the eroded land for reutilization and using the least expensive of the two values. The cost of filling/restoring the improved property is based on a typical 100'x50' lot for the different depths, widths and cubic yards of erosion produced by storms. The cost of filling/restoring the eroded improved property was determined to be the cheaper of the two and the cost of fill was prorated for the width of each reach to estimate total damages.

300. Erosion damages for infrastructure are also calculated. The infrastructure damage category included damage to roads, utilities, the boardwalk, bulkhead, and geotubes. The replacement cost of infrastructure does not necessarily relate to the number of structures in the area. Road and utilities replacement costs consisted of fixed and variable costs based on ranges of feet of replacement/repair. In general, the replacement cost of roads decreased with greater quantities eroded reflecting economies of scale. Distance from a reference line (back of the boardwalk) and feet of erosion per event for each road and associated utilities were used to determine damage susceptibility. Atlantic City alone has over sixty streets which are perpendicular to the boardwalk.

301. The boardwalk in Atlantic City is approximately 18,000 feet long and ranges in width from 20 feet to 60 feet, for which replacement costs ranged from $315 to $3,925 per linear foot. The following criteria were used to determine boardwalk damage susceptibility: (1) if the reference point for the boardwalk was within the wave zone for an event; (2) if the wave zone extended

beyond the front of the boardwalk; and (3) if the water elevation was greater than or equal to the boardwalk elevation. Bulkhead damage was based on selection by hydraulic engineers of a probable damage/failure event. Costs to replace bulkheads are estimated to be $900 per linear foot. Geotubes were placed on the beach in Atlantic City for erosion protection at an approximate cost of $57 per linear foot. Geotube failure was determined to occur by the 50-year storm event.

302. Damage to infrastructure and the boardwalk in particular has historically been significant, especially in Atlantic City. Boardwalk damage constituted 40% of the $330,000 in municipal damages caused by the March 1984 storm. The December 1992 storm caused approximately $1.2 million dollars in municipal damage to Atlantic City. Several hundred feet of the boardwalk was destroyed or damaged. These damage estimates represent claims considered eligible by the Federal Emergency Management Agency (FEMA) and not all costs incurred from the storms.

303. IMPROVED PROPERTY DAMAGES. Annual damages for without project conditions of improved property are provided in Table 23.

Table 23

Improved Property Without Project Expected Annual Damage (In $000s, March 1994 Price Level)	
Reach	Annual Damages
Atlantic City Inlet	0
Atlantic City Oceanfront	130
Ventnor, Margate, Longport	256
Total Improved Property Damage	386

304. Erosion damages for infrastructure are also calculated. Costs to replace the bulkheads were estimated to be $900/linear foot. The replacement cost of roads was not a fixed value and decreased with greater quantities eroded reflecting economies of scale. The total without project annual damages for developed property and infrastructure including roads, utilities, bulkhead and boardwalk, are provided in Table 24.

Table 24

Infrastructure Without Project Expected Annual Damage (In $000s, March 1994 Price Level)	
Reach	Annual Damages
Atlantic City Inlet	187
Atlantic City Oceanfront	2,309
Ventnor, Margate, Longport	660
Total Infrastructure Damage	3,156

305. WAVE-INUNDATION DAMAGES. A structure is considered to be damaged by a wave when there is sufficient force in the total water elevation to completely damage a structure. Partial wave damages are not calculated; instead the structure is subjected to inundation damages. Large masonry structures like high rise condominiums will not experience failure by wave damage. Because of the large presence of such structures along the oceanfront in Atlantic City, no wave damages are present. On the contrary, the residential communities of Ventnor, Margate,

and Longport have typical frame single family beach houses along the oceanfront that do experience wave damage.

306. The percentages of total replacement cost used to calculate damages by the depth-damage function curves for inundation damages reflect various characteristics of a structure. The depth-damage curves display the percent of damage at various depths relative to the first floor. Examples of the depth-damage curves are displayed in Table 25. The depth-damage curves used to estimate the damage to structures were derived from previous studies of saltwater areas and FIA (Federal Insurance Administration) curves. The distinguishing characteristics were construction type (frame, concrete block, or masonry) and number of stories in a structure.

307. Depth Damages. Over 1,200 structures were included in the economic analysis database. The structure inventory consists of single family homes, multi-family dwellings such as apartment and condominium buildings, and commercial establishments such as hotel-casinos, multi-unit retail structures, arcades, malls and office and public buildings. Local officials, and redevelopment agencies have embarked upon substantial development plans for the Inlet area. Almost 200 townhouses have been constructed recently. Land acquisition and remediation has been conducted to commence construction of two mid-rise multi-unit complexes of similar construction to an existing multi-unit building (Ocean Terrace) in the area, and conceptual plans for a water park have been designed. In Atlantic City, the inclusion of multi-unit commercial structures results in higher equivalent annual damages than a database weighted with more residential structures. The database consists of over 30 structures classified as hotels/casinos, a shopping mall, and a convention center. The estimated total replacement cost for all structures is over 600 million dollars and contain 200 million dollars in content replacement cost. The average replacement cost for residential structures included in the database for Atlantic City Inlet, Atlantic City Oceanfront, and Ventnor, Margate, Longport are $196,00, $248,000, and $294,000, respectively. The average replacement cost for commercial structures and contents (hotels/casinos, malls, etc.) included in the database for Atlantic City Inlet, Atlantic City Oceanfront, and Ventnor, Margate, Longport are $3.9, $2.9, and $1.8 million, respectively. The inventory of structures in each area extended approximately one block from the oceanfront or inlet frontage. Most structures are located within 700 feet of the reference line. Structures are susceptible to wave-inundation, and erosion damages. Wave-inundation damage is more prevalent than erosion due to the presence of shore protection structures such as bulkheads, geotubes, and seawalls. Ninety-five percent of the damage is attributed to wave-inundation and 5 percent is due to erosion.

TABLE 25
EXAMPLE DEPTH DAMAGE RELATIONSHIPS

S03 (2 story, no basement, residential structure)
Depth Damage (expressed as a decimal)

Depth	Damage
-2	0
-1	.01
0	.10
1	.24
2	.30
3	.36
4	.39
5	.42
6	.47
7	.49
8	.56
9	.64
10	.67

S15 (1 story, masonry, no basement, commercial structure)
Depth Damage (expressed as a decimal)

Depth	Damage
-2	0
-1	.01
0	.05
1	.21
2	.29
3	.38
4	.46
5	.48
6	.53
7	.55
8	.59
9	.67
10	.73

308. BACK BAY RESIDUAL DAMAGES. COSTDAM was also run for the stages associated with the back bay (still-water) inundation to determine the corresponding damages. The results, listed in Table 10, represent inundation damages that will not be eliminated by a project on the oceanfront of Longport. These back bay induced residual damages total $223,000 in annual damages. This avoids overestimating benefits in the with project condition for those cases where damages are reduced or eliminated for structures once eroded or damaged by wave but may still incur some damages due to inundation from the back bay.

Table 26

Longport Back Bay Still Water Inundation (In $000s, March 1994 Price Level)	
Reach	Annual Damages
Longport	$223

309. STRUCTURE DAMAGES. Table 27 displays equivalent annual damages for structures in Atlantic City inlet frontage, Atlantic City oceanfront, and Ventnor, Margate, Longport, respectively. Annual damages for Atlantic City inlet and Atlantic City oceanfront are $422,000 and $2,738,000, respectively. Annual damages for Ventnor, Margate, Longport are $5,159,000.

Table 27

Structures Without Project Expected Annual Damage (In $000s, March 1994 Price Level)	
Reach	Annual Damages
Atlantic City Inlet	422
Atlantic City Oceanfront	2,738
Ventnor, Margate, Longport	5,159
Total Structure Damage	8,319

310. EMERGENCY/CLEAN-UP COSTS. Clean-up costs for individual structures are based on the time for clean-up and additional meal and travel costs. Travel and meal costs are included as opposed to evacuation costs because the vast majority of residential structures and even many commercial structures are occupied only on a seasonal basis, and even then, not by the structure's owner. Clean-up costs are only applied to those structures affected by a particular storm event.

311. Emergency and clean-up costs are also calculated for public entities, including local, county and state governments and non-profit emergency service organizations. These costs are based on Federal Emergency Management Agency (FEMA) Damage Survey Reports for the March 1984

and December 1992 storms, which had stage frequencies of approximately 10 and 20 year events. Because of the lack of historical information, emergency and clean-up costs for larger events are extrapolated.

312. The number of structures affected and the associated emergency costs for each storm event are in Table 28. Average annual damages for (all affected) individuals in Atlantic City inlet, Atlantic City oceanfront, and Ventnor, Margate, Longport are $2,000, $13,000 and $29,000, respectively. Average annual damages for (all affected) public entities are $5,000, $112,000, and $106,000 respectively.

Table 28

Structures Affected and Emergency/Clean-up Costs (in $000s, March 1994 Price Level)							
ATLANTIC CITY INLET	5yr	10yr	20yr	50yr	100yr	200yr	500yr
Structures	11	12	13	15	32	35	41
Individual Clean-up Costs $	4	5	6	11	28	57	117
Municipal Clean-up Costs $	3	6	25	50	103	227	289
ATLANTIC CITY OCEANFRONT	5yr	10yr	20yr	50yr	100yr	200yr	500yr
Structures	31	69	114	174	199	231	254
Individual Clean-up Costs $	12	27	44	111	231	475	959
Municipal Clean-up Costs $	87	174	717	1062	2417	3379	5330
VENTNOR, MARGATE, LONGPORT	5yr	10yr	20yr	50yr	100yr	200yr	500yr
Structures	32	120	242	325	749	851	890
Individual Clean-up Costs $	12	46	93	218	600	1239	2493
Municipal Clean-up Costs $	97	194	518	705	3015	4041	4859

TOTAL AVERAGE ANNUAL CLEANUP COSTS

ATLANTIC CITY INLET: (all) Individuals: $2,000
Public entities: $5,000

ATLANTIC CITY OCEANFRONT: (all) Individuals: $13,000
Public entities: $112,000

VENTNOR, MARGATE, LONGPORT: (all) Individuals: $29,000
Public entities: $106,000

313. TOTAL ANNUAL WITHOUT PROJECT DAMAGES. Total annual damages for structures, infrastructure and improved property is displayed by cell in Table 29.

Table 29

Total Damages for All Categories Without Project Expected Annual Damage (In $000s, March 1994 Price Level)	
Reach	Annual Damages
Atlantic City Inlet	609
Atlantic City Oceanfront	5,177
Ventnor, Margate, Longport	6,075
Total Damages	11,861

PLAN FORMULATION

314. The purposes of the Plan Formulation section are to provide background on the criteria used in the formulation process, to present the procedures followed in evaluating various alternatives, and the subsequent designation of the selected plan. The formulation process involved establishment of plan formulation rationale, identification and screening of potential solutions, and assessment and evaluation of detailed plans which are responsive to the identified problems and needs.

PLANNING OBJECTIVES

315. General planning objectives for the Absecon Island study are to take an integrated approach to the solution of the erosion and inundation problems along the oceanfront of Atlantic City, Ventnor, Margate and Longport, and problems of storm vulnerability along Atlantic City's Absecon Inlet frontage. The study will strive to:

1. meet the specified needs and concerns of the general public,
2. respond to expressed public desires and preferences,
3. be flexible to accommodate changing economic, social and environmental patterns and changing technologies,
4. integrate with, and be complementary to, other related programs in the study area, and
5. be implementable with respect to financial and institutional capabilities and public support.

316. Specific objectives include the following:

1. Reduce the impacts of long term erosion along the ocean beaches of Absecon Island,
2. improve the retention of beach nourishment in Atlantic City and Longport,
3. improve the stability and longevity of beaches and shore protection structures,
4. reduce the incidence of storm flooding and wave damage along both the Absecon Island ocean and inlet frontages,
5. reduce maintenance of hardened shore protection structures found along the shoreline,
6. preserve recreational and commercial boating opportunities through Absecon and Great Egg Harbor Inlets,

7. enhance recreational beach use opportunities along the Absecon Island as an incidental benefit, and

8. where possible, preserve and maintain the environmental character of the areas under study, including such considerations as aesthetic, environmental and social concerns, as directly related to plans formulated for implementation by the Corps.

PLANNING CONSTRAINTS

317. Planning constraints are policy, technical, or institutional considerations that must be considered to successfully meet the planning objectives. The formulation of all alternative shore protection designs will be conducted in accordance with all Federal laws and guidelines established for water resources planning.

318. TECHNICAL CONSTRAINTS. These constraints include physical or operational limitations. The following criteria, within a planning framework, were adopted for use in plan formulation:

1. Federal participation in the cost of restoration of beaches shall be limited so that the proposed beach will not extend seaward of the historical shoreline of record.

2. Natural berm elevations and foreshore beach slopes should be used as a preliminary basis for the restoration of beach profiles.

3. The design tide and wave data are based on calculations and investigations as detailed in the Existing Conditions section of this report. The design of protective structures should, as a minimum, demonstrate that they will satisfactorily perform for design events up to and including the annual frequency which has a 50 percent probability of being exceeded during the economic life of the feature.

4. Plans must represent sound, safe, acceptable engineering solutions.

5. Plans must comply with Corps regulations.

6. Analyses are based on the best information available using accepted methodology.

319. ECONOMIC CONSTRAINTS. Economic constraints limit the range of alternatives considered. The following items constitute the economic constraints foreseen to impact analysis of the plan to be considered in this study and any subsequent formulation of alternatives.

1. Analyses of project benefits and costs are conducted in accordance with Corps of Engineers' guidelines and must assure that any plan is complete within itself, efficient and safe, and economically feasible in terms of current prices.

2. Economic evaluations of project modifications must assume that authorized dimensions are maintained and will evaluate the incremental justification of modifications.

3. To be recommended for project implementation, tangible benefits must exceed project economic costs. Measurement shall be based on the NED benefit/cost ratio being greater than 1.0.

4. The benefits and costs are expressed in comparable quantitative economic terms to the maximum practicable extent.

a. The costs for cycles 1 & 2 alternative plans of development were based on preliminary designs and investigations, estimates of quantities, and January 1994 price levels. Annual charges are based on a 50-year amortization period and an interest rate of 8.0 percent. The annual charges also include the cost of maintenance and replacement.

b. The costs for cycle 3 alternative plans of development were based on detailed designs and investigations, estimates of quantities and costs, and October 1995 price levels. Annual charges are based on a 50-year amortization period and an interest rate of 7 5/8 percent. The annual charges also include the cost of maintenance and replacement.

320. REGIONAL AND SOCIAL CONSTRAINTS.

1. The needs of other regions must be considered, and one area cannot be favored to the unacceptable detriment of another.

2. Consideration should be given to public health, safety, and social well-being, including possible loss of life.

3. Plans should minimize the displacement of people, businesses and livelihoods of residents in the project area.

4. Plans should minimize the disruption of normal and anticipated community and regional growth.

321. INSTITUTIONAL CONSTRAINTS. The formulation of alternative projects will be conducted in accordance with all Federal laws and guidelines established for water resources planning. According to the Planning Guidance Notebook (ER 1105-2-100), Section IV--Shore Protection, "Current shore protection law provides for Federal participation in restoring and protecting publicly owned shores available for use by the general public." Typically, beaches must be either public or private with public easements/access to allow Federal involvement in providing shoreline protection measures. Private property can be included, however, if the "protection and restoration is incidental to protection of publicly owned shores or if such protection would result

in public benefits". Items which can affect the designation of beaches being classified as public include the following:

1. A user fee may be charged to aid in offsetting the local share of project costs, but it must be applied equally to all.

2. Sufficient parking must be available within a reasonable walking distance on free or reasonable terms. Public transportation may substitute for, or compliment, local parking, and street parking may only be used if it will accommodate existing and anticipated demands.

3. Reasonable public access must be furnished to comply with the planned recreational use of the area.

4. Private beaches owned by beach clubs and hotels cannot be included in Federal shore protection activities if the beaches are limited to use by members or paying guests.

5. Publicly owned beaches which are limited to use by residents of the community are not considered to be open to the general public and cannot be considered for Federal involvement.

322. ENVIRONMENTAL CONSTRAINTS. Appropriate measures must be taken to ensure that any resulting projects are consistent with local, regional and state plans, and that necessary permits and approvals are likely to be issued by the regulatory agencies. Further environmental constraints relate to the types of flora and fauna which are indigenous and beneficial to the ecosystem. The following environmental and social well-being criteria were considered in the formulation of alternative plans.

1. Consideration should be given to public health, safety, and social well-being, including possible loss of life.

2. Wherever possible, provide an aesthetically balanced and consistent appearance.

3. Avoid detrimental environmental and social effects, specifically eliminating or minimizing the following where applicable:

(1) Air, noise, and water pollution;

(2) Destruction or disruption of man made and natural resources, aesthetic and cultural values, community cohesion, and the availability of public facilities and services;

(3) Adverse effects upon employment as well as the tax base and property values;

(4) Displacement of people, businesses, and livelihoods; and,

(5) Disruption of normal and anticipated community and regional growth.

4. Maintain, preserve, and, where possible and applicable, enhance the following in the study area:

(1) water quality;

(2) the beach and dune system together with its attendant fauna and flora;

(3) wetlands, if any;

(4) sand as a geological resource;

(5) commercially important aquatic species and their habitats;

(6) nesting sites for colonial nesting birds.

CYCLES 1 AND 2 PLAN FORMULATION

323. Alternatives were considered separately for the two specific problem areas defined earlier, namely the Absecon Inlet frontage of Atlantic City, and the Absecon Island oceanfront which includes Atlantic City, Ventnor. Margate and Longport.

324. Alternative measures considered for implementation in the study area are classified under nonstructural measures and structural measures. Nonstructural measures are those measures which control or regulate the use of land and buildings such that damages to property are reduced or eliminated. No attempt is made to reduce, divert, or otherwise control the level of erosion. Structural measures are generally those which act to block or otherwise interfere with erosive coastal processes or which restore or nourish beaches to compensate for erosion.

325. Measures were evaluated individually and in combination on the basis of their suitability, applicability, and merit in meeting the specific objectives of the study. In addition, technical and economic feasibility and environmental and social acceptability were of significant concern in the screening of the measures. The potential for local support was not a major factor since the State of New Jersey and locals embrace both traditional and non-tradition shore protection measures if there is a probability of success coincident with prudent land usage. Many of the State's guidelines, policies and cost-sharing procedures are similar to the Federal government as well.

ABSECON INLET FRONTAGE OF ATLANTIC CITY

326. CYCLE 1 ALTERNATIVES - ABSECON INLET. Alternative cycle 1 measures

considered for this area are as follow:

1. Nonstructural Measures

- o No action
- o Evacuation from areas subject to erosion and storm damage
- o Regulation of future development

2. Structural Measures

- o Lengthen the Brigantine Jetty
- o Realign the Absecon Inlet channel
- o Beach restoration
- o Relocation of the boardwalk
- o Bulkheads with and without revetments
- o Navigation type breakwater at the entrance of Absecon Inlet
- o Wave breaking structure
- o Perched beach using geo-tubes

327. It is noted that all the above alternatives were evaluated with the goal of providing similar storm damage protection. The following paragraphs summarize the objectives and evaluation of each of the above alternatives considered in cycle 1.

328. Nonstructural Measures. Following are discussions of the nonstructural measures considered under the Absecon Inlet cycle 1 analysis.

329. No Action. The no action alternative involves no measures to provide erosion control, recreational beach or storm damage protection to structures landward of the beach front. This alternative would not check the continuing erosion of the beaches, nor would it prevent property from being subjected to higher storm damages from beach recession, flooding and wave attack. Existing groins and jetties would continue to deteriorate, further accelerating the loss of beach. This plan fails to meet any of the objectives or needs of the study. Therefore, this alternative will not be considered in cycle 2.

330. Evacuation From Areas Subject to Erosion and Storm Damage. Permanent evacuation of existing developed areas subject to inundation involves the acquisition of lands and structures thereon either by purchase or through the exercise of powers of eminent domain, if necessary. Following this action, all commercial and industrial developments and residential property in areas subject to erosion are either demolished or relocated to another site. High rise condominiums, health care facilities and other large structures found on the inlet would require relocation. Additionally, roads, railroads, water supply facilities, electric power, and telephone and sewerage utilities would also have to be relocated. Lands acquired in this manner could be used for undeveloped parks, or other purposes, that would not result in material damage from erosion. The level of development and ongoing re-development along the inlet frontage would make this measure prohibitively expensive. Therefore, this alternative will not be considered in cycle 2.

331. Regulation of Future Development. Regulation or land use controls could be enacted through codes, ordinances, or other regulations to minimize the impact of erosion on lands which are being re-developed in the future. There are regulations in place to control future development and reduce susceptibility to damage. By restricting usage to parks or natural areas or limiting development to low cost or movable facilities, the potential growth of economic losses due to erosion could be minimized. Such regulations are traditionally the responsibility of State and local governments. This measure lends itself to relatively large, continuous undeveloped areas rather than developed areas. The re-development of the inlet area is presently occurring on the bay side and is presumably to code and meets FEMA flood insurance criteria. Therefore additional regulation to prevent virtually all re-development would have to be enacted for this option to work. This alternative will not be considered in cycle 2.

332. Structural Measures. Following are discussions of structural measures considered under the Absecon Inlet cycle 1 analysis. The first three measures were proposed previously in the Atlantic City, NJ, Beach Erosion Control Study, House Document No. 538, 81st Congress, 2nd Session, 1950.

333. Lengthen the Brigantine Jetty. The Brigantine Jetty, to the northeast of Absecon Inlet, was designed and modeled by the Corps and subsequently authorized by Congress for construction as part of a larger project. The project was re-authorized in section 605 of the Water Resources Development Act of 1986. The design length is 5,749 feet at an elevation of +8'MLW. The jetty was to serve three purposes: 1) to prevent the elongation of Brigantine Island and thus halt the southward migration of the channel, 2) to act as a breakwater which affords protection from waves, and 3) reduce shoaling in the inlet. This project was to be constructed in conjunction with dredging the northeast side of the channel, widening it and thus relocating it closer to Brigantine.

334. The existing jetty was built by the State of New Jersey in 1952 and lengthened in 1966 to a total of 3,730 feet. The present configuration of the existing jetty is accomplishing everything for which it was designed. In fact, the channel has not been dredged since 1978 and is presently deeper than the authorized depth. As noted at the time of design, a jetty such as this has the potential to starve downdrift beaches. While the present jetty does not seem to be responsible for erosion at Atlantic City, it is effectively halting transport of sand into the inlet. Therefore it can be surmised that a lengthening of the jetty by an additional 2000 feet could have adverse effects on natural bypassing.

335. Benefits which could be obtained from lengthening this structure are that it is an essential component of the channel realignment, and it would serve as a wave breaker. However, as will be seen in the next discussion, channel realignment is not an option because the new location is already deeper than the authorized 20' depth. The merits of lengthening the jetty must rest solely on reducing incident wave energy into the inlet during northeast storms. This alternative will be considered further.

336. Realign the Absecon Inlet Channel. The purpose of moving and widening the channel was to reduce tidal currents within the inlet and hence the erosional pressure on the southwestern boundary of the inlet. As mentioned earlier, this is not a viable alternative since the depth in the

new location is already deeper than the authorized depth. Water depths in the channel reach nearly -50 feet NGVD (see figure 33). The Brigantine jetty has effectively stopped southward migration of that island and Atlantic City's Maine Avenue groins stabilize the channel location. In the original design contained in House Document 94-631, the realignment option was not to be undertaken until after the jetty was built to its design length.

Absecon Inlet Channel Depth

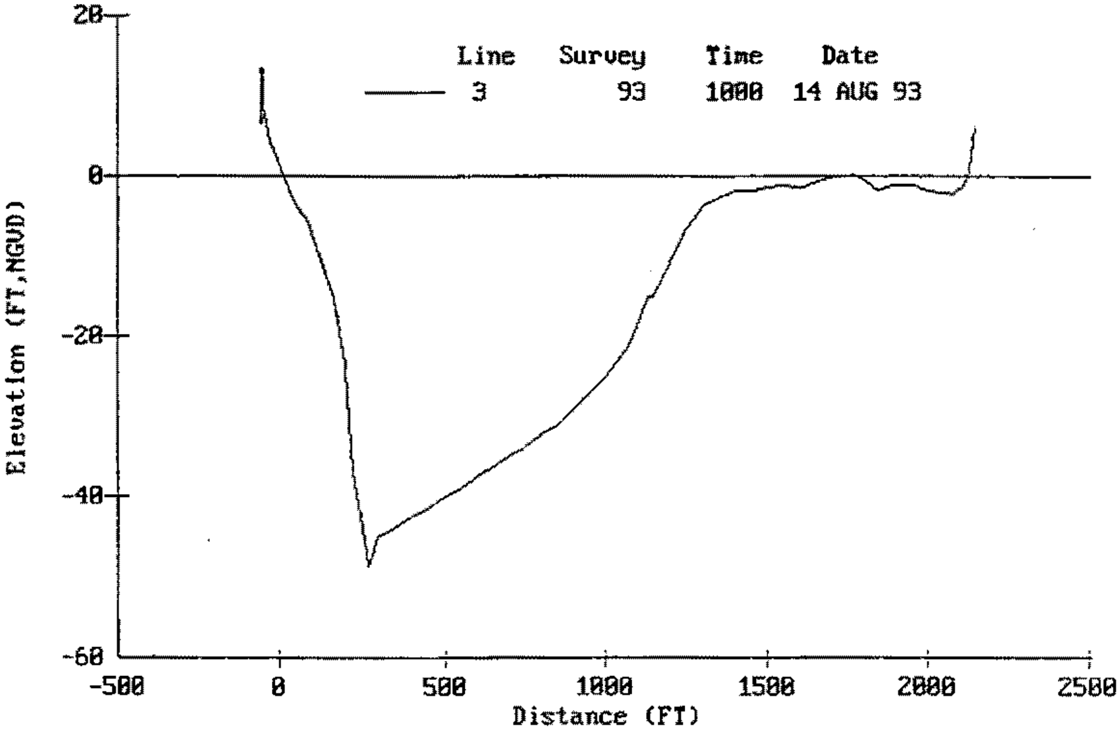


Figure 33

337. Inlet Beach Restoration. The beach restoration design found in HD 81-538 for the inlet frontage served two purposes: 1) recreation and 2) reduce wave impact. Beaches of suitable dimensions are effective in dissipating wave energy and affording protection for the upland area when maintained to properly designed berm widths and beach slopes. It was recognized however, in the authorized project, that bulkheading in this area is the more important defense against property damage. Protective beaches also remedy the basic cause of most erosion problems, that is, a deficiency in the natural sand supply which appears acute at this time.

338. The technical feasibility of this alternative in this area is questionable since the expected residence time of the beachfill is extremely short due to prevailing currents. Also, the existing slope is so steep that a tremendous quantity of sand would be required to fill the sub-aqueous portion of the beach, thus increasing the shoaling potential of the channel. The physical model tested at WES in the 1940s indicated that beachfill should only be conducted after the Brigantine Jetty is lengthened and the channel moved to the northeast. This alternative will be evaluated in cycle 2 in conjunction with lengthening the Brigantine Jetty.

339. Perched Beach Using Geo-tubes. A way to increase the residence time of a beachfill on an inlet can be to employ a perched beach concept. A sill is created, usually constructed with sand bags or geo-tubes that are located in the immediate offshore zone and run parallel to the shoreline. The sills dissipate wave energy, and thus, sand can be deposited in the region between the sills and the shoreline. The greatest advantage of beach sills is that they do not restrict the use or affect the aesthetics of the beach.

340. Disadvantages of this alternative include the questionable durability of certain components of the geo-tubes, their susceptibility to vandalism, and the depth of water at the location necessary for the structure to provide protection. The existing offshore elevation would have to be raised with beachfill, thus creating a potentially unstable foundation for the geo-tubes. Additionally, strong tidal currents would tend to undermine the tubes. Recent experiences in nearby Townsends Inlet are not favorable. Due to the considerable disadvantages, the perched beach will not be considered further to address the planning objectives of the study.

341. Relocation of the Boardwalk. A major piece of infrastructure along the inlet is the boardwalk. This structure has been repeatedly damaged during storms and repaired. One alternative to reduce this type of damage is to relocate all or portions of the boardwalk. The boardwalk which continues northwest from the Oriental Avenue Jetty is located directly in front of and above existing bulkheads and revetments for approximately 50% of its length. During storms, waves hit the bulkhead and splash upward with a force sufficient to damage the boardwalk. If the boardwalk were moved, this form of runup would cease to be a damage mechanism. However, there is little space between the existing road and the bulkhead for relocation. This alternative will be evaluated in cycle 2.

342. Wave Breaking Structure. An alternative to relocating the boardwalk is to extend the wave impact zone seaward of the boardwalk. This also removes wave induced erosion from the toe of the bulkhead and decreases wave induced superelevation at that location. The structure would be similar to a rubble revetment except that surface roughness would be maximized to dissipate wave

energy and the slope would be gradual to extend the subaerial profile seaward. This alternative will be evaluated in cycle 2.

343. Bulkhead With Revetment. A continuous bulkhead constructed along a shoreline is a viable protective measure. The primary purpose of a bulkhead is to retain or prevent erosion of upland, with the secondary purpose being to afford protection to backshore areas from wave action and inundation. Bulkheads are normally vertical walls of concrete, timber, or steel sheetpile. Depending on the wave climate to which bulkheads are exposed, beach nourishment or revetment toe protection may be a requirement in front of the bulkhead. New bulkheads would be tied in with existing bulkheads and stone groins.

344. Revetment toe protection must also be considered as part of the bulkhead alternative. A revetment is, in general, a stone or concrete face placed to protect an embankment or existing shore protection structure against erosion by wave action or currents. The bulkhead alternative along the inlet will require toe protection if other alternatives to reduce wave energy are shown not to be effective. There is the possibility that, due to settlement or erosion, the revetment could fail unless precautionary measures are taken.

345. Bulkheads along the inlet frontage have recently been refurbished (see photo #1, Appendix A) except for a 1,050 foot section between Oriental Avenue and Atlantic Avenue. This alternative will be carried into cycle 2 for this area.

346. Navigation Type Breakwater. The construction of a inlet breakwater to reduce the force of waves striking the shoreline was another protective measure considered. Offshore breakwaters are typically massive stone structures founded in relatively deep water. This alternative is similar to the extension of the Brigantine Jetty except that the movement of sand around the structure would be very different. Particular care must be taken in the design and location of the structure as erosion of the downdrift beach can occur. Gaps or breaks between structures must also be permitted to prevent the development of undesirable currents between the ends of the structures.

347. Breakwaters provide sheltered water for boating but have extremely high construction costs especially in deep water and can present a potential navigation hazard. Due to the disadvantages mentioned above, especially high construction costs, the use of a channel structure was eliminated from further consideration as a viable alternative for Absecon Inlet.

348. Cycle 1 - Applicability Screening for Absecon Inlet. During the first cycle of formulation the management measures discussed in the previous section were reviewed to determine the acceptability and potential to control erosion, wave attack and inundation in the problem area. Consideration was given to factors such as potential technical performance, whether it meets the study objectives and relative cost. Based on the information shown in Table 30, the alternative measures were screened and only those measures which were considered to have potential viability were carried forward as plans or features of plans in the next cycle of formulation.

Table 30
Absecon Inlet (Atlantic City)
Cycle 1 - First Level Screening Results

Alternative	Technical Feasibility	Meet Objectives?	Relative Cost	Further Consideration in Cycle 2?	Remarks
Nonstructural Alternatives	Partial	No	Varies	No	Could encourage development in coastal wetlands.
Beach Restoration	Partial	Partial	Moderate	Yes	Adverse environmental impacts can be minimized through coordination with environmental agencies. Existing shoreline slope may not be adequate to support stable berm. May increase inlet shoaling.
Bulkhead with revetment	Yes	Partial	Moderate	Yes	Bulkheads would require toe protection.
Navigation Type Breakwater	Partial	Partial	Very High	No	Reduces wave heights in navigation channel and on inlet shoreline. Costs must be offset by benefits to navigation and reduced periodic nourishment requirements.
Realignment of the Channel	No	No	High	No	Depth is already greater than the authorized channel throughout the inlet. Modifications may have adverse impact on channel stability.
Relocate Boardwalk	Yes	Partial	High	Yes	
Perched Beach (Geo-tubes)	Partial	Partial	High	No	Existing water depth is too deep to accommodate a perched beach with sufficient berm width to provide shore protection benefits.
Wave Breaking Structure	Yes	Partial	Moderate	Yes	Rough slope to absorb wave energy before impacting on bulkhead.
Lengthen Brigantine Jetty	Partial	Partial	Very High	Yes	May have adverse impacts on natural bypassing of sediment to Absecon Island.

349. CYCLE 2 ASSESSMENT OF ALTERNATIVES FOR ABSECON INLET. Based on the previous screening of alternatives, several plans were selected for further analysis in Cycle 2. These plans consist of one or more individual measures as appropriate to develop a suitable degree of shore protection. In addition, consideration was given to alternative methods of beach fill and periodic nourishment, various construction materials, and alternative borrow sources for sand. The following sections describe the plans considered for each problem area and discuss the technical performance, economic analyses, and environmental and social impacts associated with each plan.

350. Inlet Beach Restoration. For purposes of this evaluation, a uniform berm width of 50 feet at an elevation of +8.5' NGVD was designed for the inlet frontage. The beach nourishment alternative involves two phases. The first consists of placing the basic (minimum) protection plus any advanced nourishment. The second phase consists of nourishing and maintaining the basic protection on a periodic basis. Beach nourishment was evaluated using dredging, hydraulic pumping and mechanical methods.

351. The dredging method would use conventional floating dredge techniques with the borrow source being the ebb shoal. The sand would be pumped to the beach. The beachfill quantity used for cost estimating purposes was obtained using a typical section. More than 400,000 cubic yards of sand would be required for the inlet shoreline. Periodic nourishment was based on half the initial fill every two years.

352. About 483,000 cubic yards of fill was placed along the inlet frontage in July, 1948. More than 80% of the material was lost by May, 1950. It is assumed that a similar beachfill today would suffer the same fate unless the Brigantine Jetty were extended, and the channel were completely redesigned. Because the cost of this alternative when coupled with the extension of the jetty is very nearly equal to the total annualized damages, this alternative will not be carried into cycle 3.

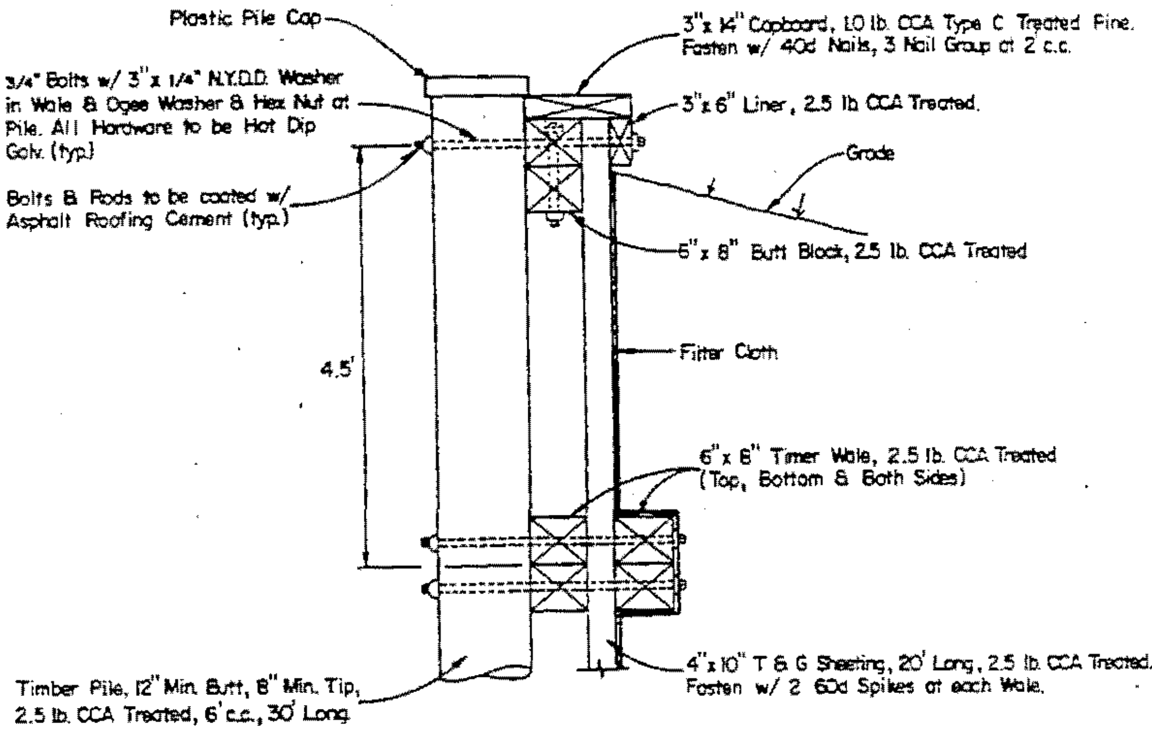
353. Lengthen the Brigantine Jetty. This alternative represents a costly method of reducing wave energy at the inlet frontage based on preliminary cost estimates, but may provide positive net benefits. Due to the potential for adverse downdrift starvation and the belief that wave energy can be reduced by less costly methods, this alternative may fall out during cycle 3.

354. Relocate the Boardwalk. Relocating the boardwalk removes the structure from the area where damage occurs. This alternative does nothing for the erosion, inundation and wave attack problems at the inlet. Therefore this alternative should be considered only in conjunction with other measures. The estimated cost of moving the boardwalk exceeds the total annualized damages and therefore will not be considered further.

355. Wave Breaking Structure. This alternative my be the least cost alternative to reducing incident wave energy and scour at the bulkhead. Once installed, its longevity would exceed a beachfill on the inlet. This alternative will be further evaluated in cycle 3.

356. Bulkhead With Revetment. Construction of a bulkhead with stone revetment for the

remaining 1,050 feet of inlet frontage would result in a continuous level of protection along the entire inlet frontage shoreline. This alternative was designed similar to the bulkhead shown in figure 34. This alternative will be evaluated in cycle 3.



TYPICAL SECTION
BULKHEAD

Figure 34

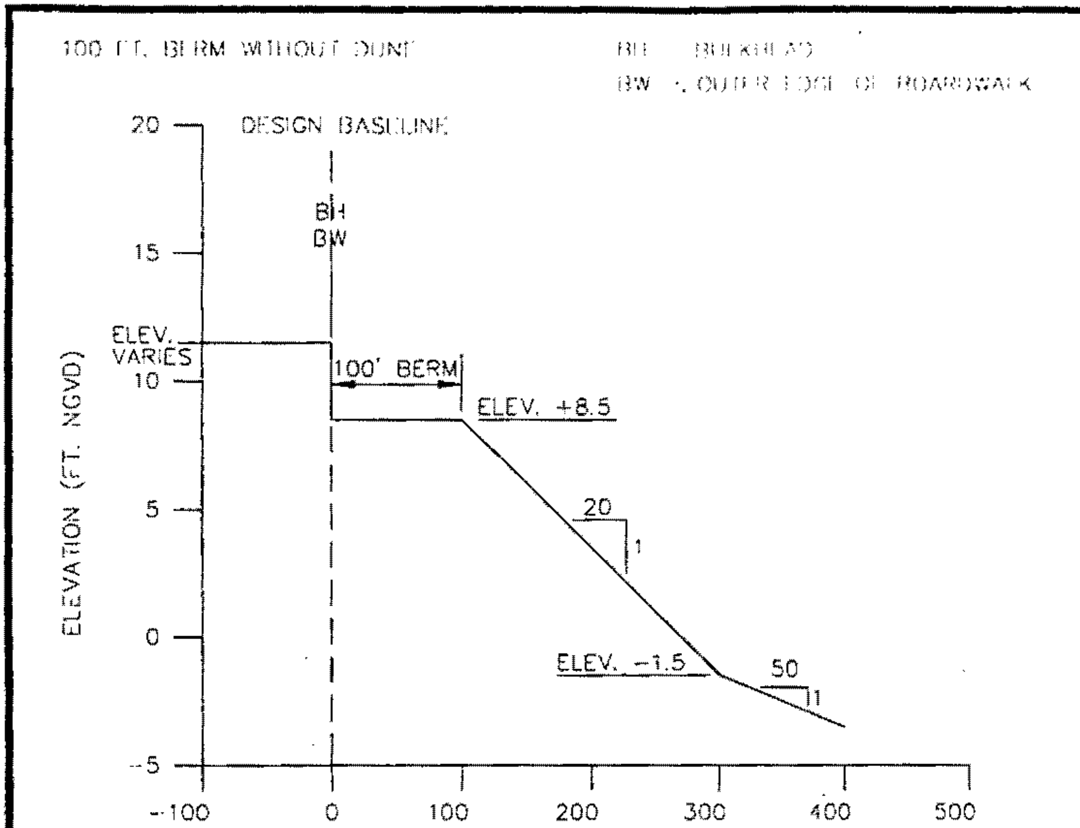


Figure 35

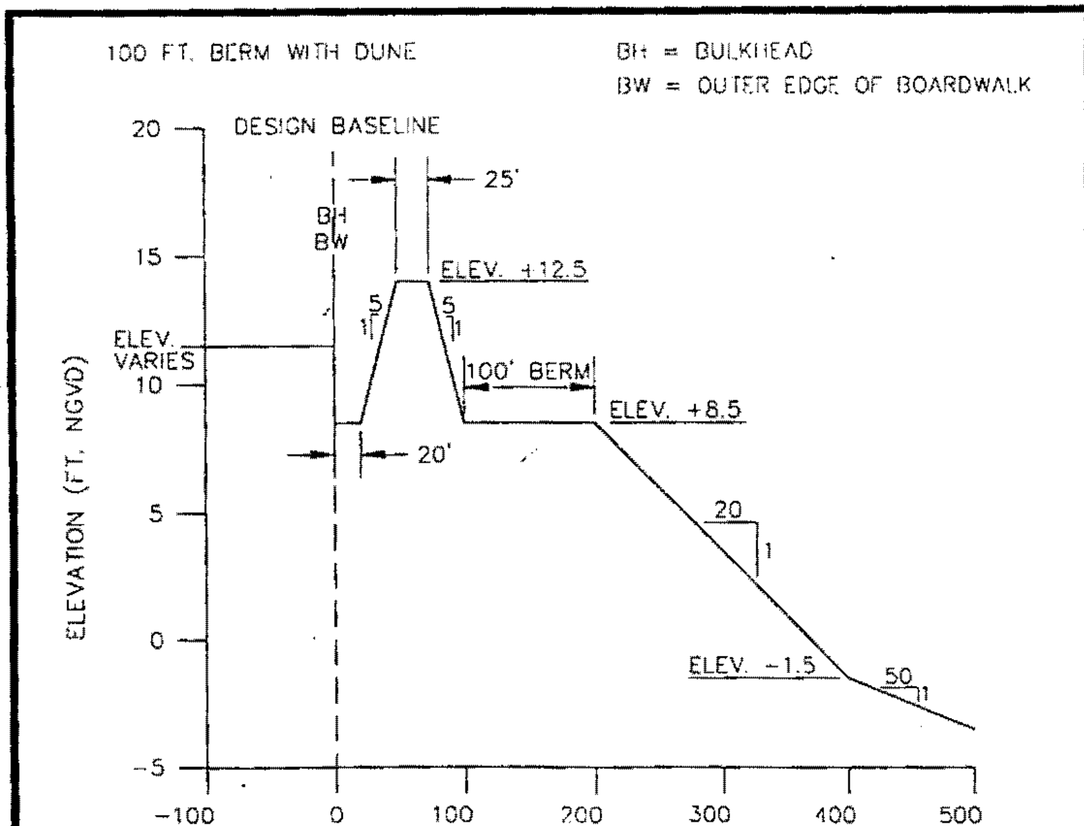


Figure 36

385. Beach Restoration With Bulkhead. In this alternative, the beachfill would not include a dune, since the bulkhead provides storm surge protection. To protect the entire length of Absecon Island at a uniform elevation would require the construction of an additional 14,075 l.f. of bulkhead. The new bulkhead would tie into the existing sections of timber bulkhead along the oceanfront. The typical bulkhead section was shown in Figure 34.

386. Since 58% of the Absecon Island ocean frontage has existing timber or concrete bulkheads and seawalls parallel to the ocean front, this alternative examined extending the timber bulkhead walls along the entire length of the study area. Under this alternative, it would require 12,700 feet of new timber bulkhead to provide a continuous line of storm protection along Atlantic City. This distance does not include those areas where the concrete foundations of casinos abut the boardwalk. Also, this does not take into account the staggered lengths of the street ends and those areas where the bulkheads facing the ocean are connected by perpendicular bulkhead sections, adding to the total bulkhead length. This is not a cost effective alternative for Atlantic City when compared to a dune, and therefore will not be included in the cycle 3 analysis.

387. In contrast, Ventnor, Margate and Longport would require approximately 1400 linear feet of bulkhead, primarily at road ends, to complete a continuous line of storm protection. This assumes that tieing into the existing bulkhead system is feasible. This alternative will be investigated further in cycle 3.

388. Another option for improving the bulkhead-seawall system for Absecon Island would involve replacing those sections that have top elevations below +9.5 NGVD and which are in poor condition (see photo #16, Appendix A). This occurs primarily at the street ends in Ventnor, Margate and Longport, as most of the residents in these communities who own beachfront property maintain the bulkheads at a top elevation of at least +9.5 NGVD and the majority are kept in fair to good condition. Approximately 25 percent of the bulkheads protecting the street ends in these shore communities would need to be replaced under this option. This results in a total length of 1400 linear feet.

389. While bulkheads will protect upland areas, beach restoration will limit erosion in front of the bulkheads and will provide additional protection to upland areas. Since bulkheads do not interact with the littoral transport, it will not reduce nourishment cycles as a groin field would. There may be institutional problems with the concept of a contiguous bulkhead line due to the potential for moving development seaward in some locations. This alternative will be evaluated in cycle 3.

390. Beach Restoration With Groins. The longevity of a beach restoration project may be short depending upon the shoreline's vulnerability and the frequency and intensity of coastal storms. Frequent renourishment of a section of beach may be required to maintain a given level of protection. The use of beach stabilization structures, such as groins, may be appropriate to increase the amount of time that placed sand remains on the beach. Economic justification for the cost of the groins or other beach stabilization structures is the savings realized by lengthening the time interval between renourishments.

391. Groins are generally constructed perpendicular to the shoreline and control the rate of

longshore transport through a project area. If properly designed, they are effective in stabilizing beaches and beach fill projects where sand is typically lost by longshore transport. Functional design of a groin or groin system should maximize the amount of material accumulated or maintained on the updrift side and minimize erosion downdrift of the structure. Important design parameters to consider include the proper siting and type of groin as well as groin length, height, crest width, alignment, spacing, and permeability.

392. The Absecon Island coastline has numerous existing groins as described in Appendix A. Detailed shoreline change modeling which includes the testing of various alternative configurations are required to properly design and optimize beach restoration and additional groin construction for the study area. However, initial recommendations for beach restoration with the use of groins have been developed for Cycle 1 and 2 level efforts. These recommendations were based on the anticipated need to stabilize beach fill at particular sections of the Absecon Island shoreline. Numerous groins and piers already exist on the Atlantic City shoreline to the northeast of the Ocean One Pier, however, no groins are present for approximately 4 miles to the southwest of Ocean One. This area has historically experienced downdrift erosion and shows substantial erosion and inundation damages for the without project conditions. Two groins at approximately 1200 ft spacing are a viable alternative to provide stabilization for beach fill in this area. No additional groins are recommended for Ventnor or Margate.

393. An additional alternative is that six stone groins be constructed in Longport to increase natural beach width and to maintain placed beach fill. Several dilapidated timber groins which are essentially no longer functional are present along Longport's shoreline. The narrow and steep beach profile in this area suggests that additional structures may be required to effectively stabilize beach restoration material.

394. Extend the Longport Terminal Groin. A cost estimate was developed for extending the terminal groin from 500 feet to 1000 feet. Because costs are less than the total damages, this alternative will be evaluated further in cycle 3. However, potential benefits to periodic nourishment may not outweigh potential negative impacts to the Great Egg Harbor Inlet ebb shoal complex.

395. Cycle 2 - Applicability Screening for Absecon Island Oceanfront. During the second cycle of formulation the measures discussed in the previous section were reviewed to determine their social and environmental acceptability and their cost effectiveness. Preliminary without project annualized damages were compared to preliminary annualized costs to ascertain the potential for positive net benefits. Both damages and costs were calculated using simplifying assumptions and are therefore subject to change in cycle 3. Based on the information shown in Table 33, the alternative measures were screened and only those measures which were considered to have potential viability were carried forward as plans or features of plans in the detailed cycle 3 plan formulation.

Table 33
Absecon Island Ocean Front
Cycle 2 - Second Level Screening Results

Alternative	Design Considerations	Environmental Considerations	Social Considerations	Preliminary Annualized Costs	Total Annualized Damages	Further Consideration in Cycle 3?	Remarks
Beach Restoration	100' Berm, +8.5 ft. NGVD.	Smother organisms. Kill organisms in borrow area. Can increase nesting and beach habitat.	Provide usable beach area.	$1,329,000	$16,025,000	Yes	Adverse environmental impacts can be minimized through coordination with environmental agencies.
Beach Restoration with Dune and Groin field	AC: Two stone groins, 1200' apart, 400' length from 10'MLW to 7' MLW at seaward end.	Same as beach restoration.	Same as beach restoration but there may be aesthetic problems with hardened structures.	$607,000 (Atlantic City only)	$6,943,000 (Atlantic City only)	Yes	Costs must be offset by reduced periodic nourishment requirements.
	Longport: Six stone groins, 100' apart, 400' length from 10'MLW to 7' MLW at seaward end.			$1,375,000 (Longport only)	$4,943,000 (Longport only)	Yes	
Beach Restoration with Bulkheading (no dune)	100' Berm, 12,700 l.f. bulkhead (Atlantic City).	Same as beach restoration.	Same as beach restoration.	$1,071,000 (Atlantic City)	$6,943,000 (Atlantic City)	No	Bulkheads perform the same function as dune but are more costly. Road ends are existing low points in elevation.
	100' berm, 1400 l.f. bulkhead at road ends (Margate, Ventnor & Longport).			$1,198,000 (Ventnor, Margate & Longport).	$9,082,000 (Ventnor, Margate & Longport).	Yes	
Beach Restoration with Dune	185' berm and dune width. Berm: +8.5 ft. NGVD. Dune: 25 ft top width, +12.5 ft. NGVD.	Same as beach restoration, in addition, enhancement of backshore environment.	Same as beach restoration but there are those who are inconvenienced by dunes.	$2,118,000	$16,025,000	Yes	Provides buffer and sediment stockpile during storms and can provide aesthetic value by planting with dune grass.
Extend Longport Terminal Groin	1000' total length.	Temporary dredging impacts such as increased turbidity and destruction of benthic habitat.		$128,000	$4,943,000 (Longport only)	Yes	Costs must be offset by reduced periodic nourishment requirements. Possible effects on the Great Egg Harbor Inlet ebb shoal.

CYCLE 3 PLAN FORMULATION

396. RECOMMENDED PLANS FOR CYCLE 3 ANALYSIS. The cycle 1 and cycle 2 screening process eliminated many of the potential alternative measures. The alternatives recommended for further consideration in cycle 3 (refer to tables 31 and 33) are listed below. In cycle 3, designs will be formulated and optimized to develop the NED plan for the two problem areas described in this report.

397. Absecon Inlet Frontage of Atlantic City.

1. Bulkheading with revetment.
2. Wave breaking structure.
3. Lengthening of the Brigantine Jetty.

398. Absecon Island Oceanfront.

1. Beach restoration.
2. Beach restoration with dunes.
3. Beach restoration with bulkheads in Ventnor, Margate and Longport.
4. Beach restoration with groins in Atlantic City and Longport.

399. Incremental Analysis. In order to properly formulate the NED plan, three discrete incremental reaches were established for cycle 3, one for the inlet frontage of Atlantic City and two for the Absecon Island oceanfront split between Atlantic City and the communities of Ventnor, Margate and Longport. The incremental reaches are based on existing economic and physical conditions, while also ensuring that the recommended project is constructable, and that each reach functions properly and independently. These reaches are based on the type and extent of development, similarities in the typical beach and upland profiles comprising the without-project condition, and background erosion rate. Also taken into account is the existence of groins, bulkheads and boardwalks. Sufficient differences exist in the without-project conditions for the three reaches to effect project optimization.

400. CYCLE 3 ALTERNATIVES - ABSECON INLET. Along the Absecon Inlet frontage in Atlantic City, most damages occur in those areas that are not protected by the existing timber bulkhead constructed along Maine Avenue, or where the bulkheads direct wave energy upwards, thereby damaging the boardwalk. In these areas, flooding and boardwalk damage occurs on a regular basis. Damages to the boardwalk are generally caused by direct wave attack, and can occur during minor storm events. The cycle 3 alternatives that were analyzed to prevent these damages include construction of a timber bulkhead to complete the line of protection along the inlet, extension of the north (Brigantine) jetty and an inshore wavebreaker.

401. Bulkheads. The bulkhead alternative consists of constructing two separate sections; one from Madison Ave. to Melrose Ave., for a length of 550 feet, and one section from Atlantic Ave. to Oriental Ave., for a length of 1,050 feet. The timber sheet-pile bulkhead would tie in to the existing bulkhead at both locations. From Atlantic to Oriental Aves., the bulkhead would be

located at the seaward edge of the existing boardwalk. Both sections of bulkhead would be constructed to a top elevation of +14 NGVD, with pile anchors and tie-backs. A revetment of rough quarrystone will be constructed to an elevation of +5 NGVD on the seaward side of the bulkhead. This bulkhead would prevent damages from inundation and wave attack. Erosion from channel migration would not be prevented by this option, however the existing groin field and double jetties serve to limit the channel from further southerly migration.

402. Wavebreaker. The purpose of this alternative is to protect the boardwalk by dissipating a large enough portion of the wave energy to remove the boardwalk from the 3 foot wave zone. The breakwater is proposed to be constructed at a location 200 feet offshore of the seaward edge of the existing boardwalk. Locating the structures further offshore reduces their effectiveness and is impractical due to existing water depths (see figure 33). Constructing the wavebreakers between the existing groins, however, leads to concerns about scour since a closed compartment would be created thereby increasing velocities through the gaps. Therefore, a low-crested elevation is preferred.

403. Three different designs were developed for the wavebreaker alternative. The location and overall conceptual design remained the same for each, but the crest elevations were varied. Top elevations were determined by taking into account the stage elevation for higher frequency events. The design consisted of separate segments constructed in the first three groin cells beginning at the Oriental Avenue jetty. Each segment would be constructed with a crest width of 12 feet, and side slopes of 1V:3H. Materials will consist of a layer of 12" size bedding stone, 50 to 100 lb. matstone, 750lb. to 1 ton corestone, and 10 to 15 ton capstone. A section of the wavebreaker is shown in Appendix A.

404. The wave transmission characteristics of a wavebreaker with a crest elevation of -0.5 feet NGVD (mean sea level) was analyzed following the methodology of Van der Meer (1991). Storm events with return periods from 5 to 500 years were investigated. The results of this analysis showed that the wave height reductions achieved by the breakwater were not sufficient to remove the boardwalk from the 3 foot damaging wave zone. Breakwaters with higher crests were investigated, but it was found that the crest elevation had to be approximately 15.0 feet NGVD to sufficiently reduce the wave height for even the most frequent storms.

405. Construction of a breakwater to such a high elevation is impractical due to scour problems and high construction costs. Additionally, this option would not prevent inundation damages. Channel migration could be slowed by this option, but only in the specific area where the wavebreakers exist. Since the existing groin field and jetties serve to keep the channel in its present location, this is not seen as a significant benefit. As can be seen in Table 34, the breakwater alternative is not justified and therefore will not be constructed.

406. Brigantine Jetty. The jetty extension consisted of adding 2000 ft to the seaward end for a total length of 5,749 ft at 8' MLW (6.5' NGVD). As described in cycle 1, the only remaining benefit gained by extending the north jetty would be a reduction in wave energy. This alternative could reduce wave heights throughout the inlet during northeasters and could result in a small reduction in inundation due to wave setup. Since the present length is effective in preventing

shoaling in the inlet, extending the jetty would almost certainly create a deficit of sand reaching the inlet littoral system. This would in turn cause adverse downdrift impacts to Atlantic City's beaches. This would also disturb the sediment budget in the inlet which is the principle source of sand for the oceanfront shore protection alternatives.

407. Sensitivity runs were performed with both the two-dimensional current model and the wave model. Analysis showed that the primary impact of lengthening the jetty was on long-term inlet processes as opposed to short-term, storm-related processes. The primary eff ect appears to be a reorientation of tidal currents to pass around the end of the new longer jetty. The newly directed currents will have sufficient velocity to erode the existing shoal at the end of the Brigantine jetty. Larger-scale inlet processes such as the transport to the flood tidal shoal or the ebb tidal transport around the Oriental Avenue jetty do not appear to be affected. A larger-scale possible effect may be the transfer of the ebb shoal farther offshore. A seaward shift of that shoal will provide increased sheltering of the Atlantic City shoreline. The sheltering, due to a decrease in water depth from the present 16 ft to the shoal depth of 10 ft, could be potentially significant for storm waves from the east to northeast, but appears to have a relatively insignificant potential effect on long-term longshore transport rates.

408. Wave reduction due to the jetty extension would be, for the most part, limited to the vicinity of the ebb shoal. Because storm wave heights impacting the shoreline are depth limited, damage would be prevented only during the more frequequent (less intense) storms. Therefore, extension of the north jetty provides limited benefits to the Absecon Inlet shoreline and this alternative cannot be justified.

409. WITH PROJECT ANALYSIS OF CYCLE 3 ALTERNATIVES - ABSECON INLET. Damages for Absecon Inlet with project alternatives are calculated using the same methodologies and databases as previously detailed in the without project conditions. The benefits for any given project are the difference between without project damages and with project damages. The storm damage reduction benefits (including emergency costs) are shown for all inlet alternatives in Table 34.

Table 34

Atlantic City Inlet
Storm Damage Reduction By Alternative
(March 1994 Price Level)

Alt.	Project Type	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
ZA	Jetty Extension	$616,000	$541,220	$74,780	12%
ZB	Bulkheads	$616,000	$184,180	$431,820	70%
ZJ	Wave Breaker	$616,000	$558,050	$57,950	9%

410. During the analysis of net benefits, figure were adjusted to the October 1995 price level. Table 35 presents the results of the comparison of average annual benefits to average annual costs for each inlet alternative.

Table 35

Atlantic City Inlet Benefit/Cost Matrix Average Annual Benefits and Costs for With Project Alternatives (October 1995 Price Level)		
		ALT. ZA
JETTY EXTENSION	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$77,031 $559,161 0.14 ($482,131)
		ALT. ZB
BULKHEADS	AVERAGE ANNAUL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	**$444,816** **$401,357** **1.11** **$43,459**
		ALT. ZJ
WAVE BREAKER	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$59,694 $484,486 0.12 ($424,792)

411. CYCLE 3 ALTERNATIVES - ABSECON ISLAND OCEANFRONT. All the remaining alternatives for the oceanfront include beachfill. Therefore, optimization of beachfill design parameters was seen as the first step in the cycle 3 process. Modelling various beachfill configurations provided insight as to the performance of the design parameters. Groin and bulkhead features were evaluated afterwards, based on that insight.

412. The communities of Ventnor, Margate and Longport are considered as one project reach. The three communities are similar both in economics and coastal hydraulics. As shown in Table 35A, there are many similarities which lead to formulating as a distinct reach. Dividing the continuously developed shorefront at the municipal boundaries is viewed as arbitrary. Additionally, performance of the project, in terms of longevity and nourishment requirements, is enhanced by formulating with one reach.

TABLE 35A
RATIONALE FOR CONSIDERING
VENTNOR, MARGATE AND LONGPORT
AS ONE PROJECT REACH

	VENTNOR	MARGATE	LONGPORT
# of Structures/Mile	137	199	235
Type of Development	Residential	Residential	Residential
Long Term Erosion Rate	0 ft/yr.	0 ft/yr.	0 ft/yr.
Direction of Littoral Transport	southwest	southwest	southwest
Orientation of Shoreline	northeast to southwest	northeast to southwest	northeast to southwest
When Seawall/Bulkhead Fails	100 year event	100 year event	100 year event
Primary Damage Mechanism	wave-inundation	wave-inundation	wave-inundation

413. Design Parameters. In cycle 3, the beach nourishment alternative required optimization of the design parameters. This was accomplished by varying parameters between a set of salient parameters established at the beginning of the analysis. In developing these parmeters the Shore Protection Manual, Coastal Engineering Tech Notes (CETN), the existing conditions in the study area and accepted coastal engineering practice were reviewed. Listed below are the boundary conditions utilized to construct a logical methodology to efficiently identify the optimum plan.

414. Berm Elevation. The natural berm elevation is determined by tides, waves, and beach slope. If the nourished berm is too high, scarping may occur, if too low, ponding and temporary flooding may occur when a ridge forms at the seaward edge. Design berm heights for each alternative have an elevation set at the natural berm crest elevation as determined by historical profiles. The average existing berm elevation in the study area varies between +7.5 and +9.0 feet NGVD. It was determined that a constructable template which closely matches the prevailing natural berm height in the study area is +8.5 ft. NGVD. This elevation was used for all designs.

415. Beachfill Slope. The slope of the design berm is based on historical profiles and the average slope of the berm, both onshore and offshore. The slope of the foreshore slope for all alternatives was set as 30H:1V down to the mean low water elevation. A 30H:1V slope closely matches the

existing slope of the beaches in the study area. Below mean low water the slope follows that of the existing profile to the point where the design berm meets the existing profile.

416. Berm Width. An interval between successive berm widths was chosen for modelling purposes. This interval is set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan can not be accurately determined. Additionally, due to the capability of the storm modeling methodology, a 50 foot interval was determined to be the most practical. The largest design berm width is based on an analysis of the average existing beach profile and determining how far offshore the design berm could go before the quantities required to construct such a berm clearly increase faster than the additional benefits captured. Based on the cycle 3 analysis, the largest berm width considered was 250 ft. The smallest berm width was determined in a similar manner, by analyzing benefits captured with minimum dimensions. Based on this analysis, the smallest berm width considered was 75 ft. This was also determined to be the minimum practicable to support a small dune.

417. Design Baseline. All berm widths are referenced from a design baseline which was established along the ocean frontage of the project study area in order to determine the alignment of the proposed beach restoration alternatives. In Atlantic City, the design baseline was set as the seaward edge of the existing boardwalk. In the city of Ventnor, the design baseline was also located at the seaward edge of the existing boardwalk up to Richards Avenue. From Richards Avenue south to the end of the boardwalk (which is the southern terminus of Ventnor), the baseline was located ten feet behind the seaward edge of the existing boardwalk. In Margate and Longport, the design baseline was located at the seaward edge of those bulkheads and seawalls which projected the greatest distance seaward. This allowed the design baseline to avoid abrupt shifts in alignment as a result of changes in the location of the seaward edge of the bulkheads. This produces a constructable beachfill template which transitions smoothly along the shoreline.

418. Dune Heights. The lowest design dune height evaluated was sufficiently above the height of the berm and existing protective structures in order to provide for additional storm damage protection, principally in the form of reduced inundation and wave attack damages. Based on bulkhead elevations and the results of the without-project analysis it was estimated that dune heights of +12.5, +14 ft., +16 ft. and +18 ft. NGVD should be considered to capture significant benefits within this study area.

419. Dune Shape. Dune top width for all alternatives was 25' except for those alternatives with a 75' berm width, in which case the dune top width was 15'. This was due to footprint requirements. Side slopes were set at 5H:1V, which was determined to be the optimum condition based on native sand grain size, and the grain size of sand to be obtained from offshore borrow areas.

420. Dune Alignment. The landward toe of the proposed dune system in Atlantic City was offset 25' seaward from the design baseline to align the design with the existing dunes and geotube reinforced dunes. The landward toe of the dune in Ventnor, Margate and Longport was located as close as possible to the design baseline taking into account piers and boardwalks. The landward beach elevation is based on the existing profiles in areas where this condition exists.

421. Design Beachfill Quantities. Quantities for each alternative were calculated by superimposing the proposed design templates on the existing beach survey cross sections. Average end area methods were used to compute the volumes.

422. Nourishment Volumes. In order to maintain as a minimum the design profile, an advanced nourishment or maintenance volume is added to the initial quantity. Without renourishing on a periodic basis, the design profile would begin to erode. Therefore, an advanced nourishment fill is placed in addition to the initial design beachfill. The nourishment volume is considered sacrificial and protects the design beachfill, and at the end of the periodic nourishment cycle, the design profile remains. For cycle 3, the nourishment period was taken to be three years. The final nourishment quantities were increased by an overfill factor of 1.4. Initial design volumes were determined by adding the advanced nourishment volumes and the design volumes obtained from the survey cross sections.

423. Storm Drain Outfalls. At the time of the last structure inventory, most outfalls as noted in the Existing Structures section of this report were intact and in fair to good condition. At the present, the condition of some of these outfalls has degraded. In Atlantic City, all outfalls are intact up to approximately the mean low water line; however, several of the existing outfall pipes have broken off at pipe sections located in the surf zone. The existing length of these outfalls is not adequate to assure unhindered drainage for those proposed beachfill alternatives having a berm width of 200 feet or greater. Therefore, costs to extend these outfalls were included for the corresponding Cycle 3 alternatives. This required extending approximately 270' of 20" diameter ductile iron pipe, and 170' of 24" diameter D.I.P., with timber support systems spaced at 18 feet. 220' of 30" diameter D.I.P., and 150' of 36" diameter D.I.P. will also be extended with timber support systems spaced at 9 feet. Several outfalls in Ventnor, Margate and Longport have also suffered damage, and in some cases have sheared off completely at the bulkhead. Costs to extend these outfalls were also included for the Cycle 3 beachfill alternatives. It was assumed that all outfalls would be replaced with 12" diameter D.I.P., for a total length of 1,650 feet, including timber support systems spaced every 18 feet.

424. Typical Beachfill Sections. Figure 37 shows a typical cycle 3 beachfill alternative superimposed on the corresponding survey cross section of the existing beach.

425. Oceanfront Bulkhead Analysis. The Cycle 2 option of raising bulkheads at street ends in Ventnor, Margate and Longport was eventually dropped for the following reasons. The existing bulkhead line in Ventnor and Margate is a conglomeration of privately installed bulkheads of varying designs and heights, interspersed with municipal structures, principally at the road ends. The present bulkhead system does not provide a continuous level of protection. Ventnor, Margate and Longport have begun raising street end bulkheads as funding allows. Those areas which have not been rehabilitated are considered infrastructure with O&M being the responsibility of the locals. Additionally, since many of the bulkheads are on private lands, rehabilitation would incur real estate costs which would be prohibitive.

426. Matrix of Oceanfront Design Parameters. Based on the design parameter assumptions discussed above, 25 combinations of berm widths and dune heights was generated. Some berm

and dune alternatives were quickly identified as non-constructable given the footprint requirements of the varying dune options as well as the toe protection required for dune stability. This eliminated six combinations from the matrix.

427. As the modelling proceeded, it became evident that the "no dune" alternatives provided virtually no inundation benefits. Inundation was sensitive to dune height and erosion was sensitive to berm width. To a small degree berm width affected the total storm stage due to the berm's ability to break the waves further offshore. Both dune and berm affected wave attack. Four no-dune alternatives were eliminated from the matrix.

428. The results of the initial model runs indicated that berm widths in excess of 200 ft. resulted in exceptionally higher quantities without a commensurate increase in the performance of reducing the storm impacts. A similar conclusion was reached with dune heights in excess of +16 ft NGVD. Additionally, dune heights greater than 16 ft are so high that they are aesthetically displeasing and block the view of the ocean, even from an elevated the boardwalk. An additional factor in screening out the larger berm widths is that in some cases they extend beyond the historic shoreline and would erode at an accelerated rate. This would greatly increase nourishment requirements, and/or, add costs to modify groins. For these reasons, an additional four alternatives were eliminated from the matrix.

429. As more alternatives were modeled and net benefits calculated, performance trends became evident. These trends helped to identify which alternatives would produce the highest net benefits and thereby optimizing the design. Table 36 summarizes the full matrix of initial alternatives and the final results of the iterative modelling process described above.

TABLE 36 MATRIX OF BEACHFILL ALTERNATIVES					
DUNE HEIGHT (FEET NGVD)	BERM WIDTH (FT)				
	75	100	150	200	250
Existing	E	E	M	E	E
12.5	M	E	E	E	E
14	X	M	M	M	E
16	X	X	M	M	M
18	X	X	X	M	E

E = Eliminated from optimization by evaluation of the performance trends of the nearest neighbor.
M = Modelled.
X = Inappropriate design template (non-constructable or insufficient footprint).

DETERMINATION OF SELECTED PLAN

430. GENERAL. Costs for both of the oceanfront reaches were developed for the alternative plans discussed above were compared with shore protection benefits to optimize the NED plan in the study area. This was accomplished using the same numerical modeling techniques utilized in the without-project analysis coupled with engineering and technical assessments to interpret model results as applied to the various alternatives. Reduced damages based on the predicted reduction in storm impacts due to the with-project alternatives were compared to the without-project results to generate project benefits. Costs for each alternative were estimated based on standard construction practices and District experience in the construction of beach nourishment projects.

431. STORM IMPACTS. The with-project conditions are the conditions that are expected based on the predicted impacts of storm events on the various project alternatives. The periodic nourishment associated with the project is designed to insure the integrity of the project design. In the case of beachfill this ensures the project design cross section will be maintained and the elimination of shoreline recession due to long-term erosion. However, coastal processes will continue to impact the shoreline along the project area. Storm-induced erosion, wave attack and inundation were evaluated for the with-project conditions using the same methodologies utilized in the without-project analyses. The following sections describe the coastal processes which were used to estimate the with-project damages.

432. <u>Storm Induced Erosion</u>. The numerical model SBEACH was applied to predict storm-induced erosion for the with-project conditions for the study area. All SBEACH input variables were identical to the without-project runs except the input profiles were modified to include the alternative beachfill

designs. As in the without-project condition, storm events from 5 to 500 year frequency were analyzed on the with-project alternatives. Model results were reviewed and analyzed for reasonableness as applied to the varying with-project alternatives. A summary of the with-project erosion results is presented in Appendix A, Section 2.

433. Tables 37 and 38 present the predicted shoreline response for the alternatives which obtained the maximum net benefits for their respective reach. The same reference line used during the without project analysis was used during the with project analysis.

Table 37 - ATLANTIC CITY
Storm Erosion Analysis Predicted Shoreline Erosion Positions
Alternative DY: 200 ft. Berm, 16 ft. Dune

Representative Profile	Erosion Position (ft)[1/]						
	5 yr	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**200 yr**	**500 yr**
1[2/]	485	495	500	525	530	630	675
2[3/]	0	0	0	0	0	400	425
3[4/]	30	85	90	100	140	165	180
4[5/]	90	100	110	170	200	320	330

Note:
1/ Distances reported are landward erosion limits of the beach profile landward of the Reference Line.
2/ Landward edge of boardwalk located at 720 ft.
3/ Erosion for portions with geotube truncated at 0; landward edge of boardwalk at 360 ft.
4/ Unfailable seawall located at 254 ft.

Table 38 - VENTNOR, MARGATE & LONGPORT
Storm Erosion Analysis Predicted Shoreline Erosion Positions
Alternative BX: 100 ft Berm, 14 ft Dune

Representative Profile	Erosion Position (ft)[1/]						
	5 yr	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**200 yr**	**500 yr**
5[2/]	90	95	100	110	170	175	175
6[2/]	115	155	160	165	170	180	180

Note:
1/ Distances reported are landward erosion limits of the beach profile landward of the Reference Line.
2/ Bulkhead located at 200 ft.

434. Storm Inundation and Wave Attack. The post storm recession profiles generated by SBEACH were used to analyze flooding and wave/run-up attack using the same methodology described in the without-project analyses. The wave height frequency and stage-frequency data utilized to assess the alternative designs was identical to that used for the without-project conditions. Appendix A, Section 2 lists the 3 foot damaging wave/run-up impact zones for the beachfill alternatives within each cell for the 5 through 500 year event as well as the total water elevation profile. Similar inundation profiles were computed for all cells in order to determine the total water level across the beach profile and into the community.

435. ECONOMIC EVALUATION OF ALTERNATIVE PLANS. During Cycle 3, economic benefits derived from the reduction in storm damages were calculated to determine the optimum plan. Once the NED plan has been identified, other benefits are determined. Recreation is not a Federal priority benefit category and is not utilized in the optimization of the selected plan. The benefits leading to project optimization are summarized below and discussed in more detail in the Economic Appendix.

436. Storm Damage Reduction. The beachfill design alternatives will reduce storm damage by reducing profile recession, flooding incurred due to high levels of ocean storm water elevations, and wave run-up and direct wave impacts. Damages were calculated using the same methodologies and databases as previously detailed in the without project conditions. The benefits for any given project are the difference between without project damages and with project damages. The storm damage reduction benefits (including emergency costs) are shown for all Atlantic City alternatives in Table 39.

Table 39

Atlantic City Oceanfront Storm Damage Reduction By Alternative (March 1994 Price Level)						
Alt.	Berm	Dune	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
CW	150	Existing	$5,302,000	$3,271,850	$2,030,150	38%
CX	150	+14	$5,302,000	$1,615,980	$3,686,020	70%
CY	150	+16	$5,302,000	$1,371,860	$3,930,140	74%
DX	200	+14	$5,302,000	$1,522,420	$3,779,580	71%
DY	200	+16	$5,302,000	$1,072,830	$4,229,170	80%
DZ	200	+18	$5,302,000	$958,310	$4,343,690	82%
EY	250	+16	$5,302,000	$912,040	$4,389,960	83%

Note: In order to extrapolate the with project storm damages for the 250 foot berm alternative, it was assumed that: (1) wave-inundation damages for Alt. EY was the same as wave-inundation damages for Alt. DY since the dune height is the same; and (2) erosion damages for Alt. EY were completely eliminated due to the wider berm width.

437. OPTIMIZATION OF ATLANTIC CITY OCEANFRONT. Optimization of the alternatives is based on storm damage reduction which is the priority benefit category. During this analysis of net benefits, figure were adjusted to the October 1995 price level. Initial fill and nourishment costs for the various project alternatives are annualized for comparison to the average annual benefits for a specific project alternative. Recreation and other incidental benefits were not used in the optimization procedure. Initial construction, periodic nourishment, and major rehabilitation costs are annualized over a 50 year project life at 7⅝%. The average annual costs are subtracted from average annual benefits to calculate net benefits and select the optimal plan which maximizes net benefits. Included in Table 40 are the average annual benefits and costs, the net benefits and benefit-cost ratio for storm damage reduction and reduced maintenance benefits. Plan DY with a 200' berm and a dune at +16 NGVD is the optimal plan for Atlantic City.

Table 40

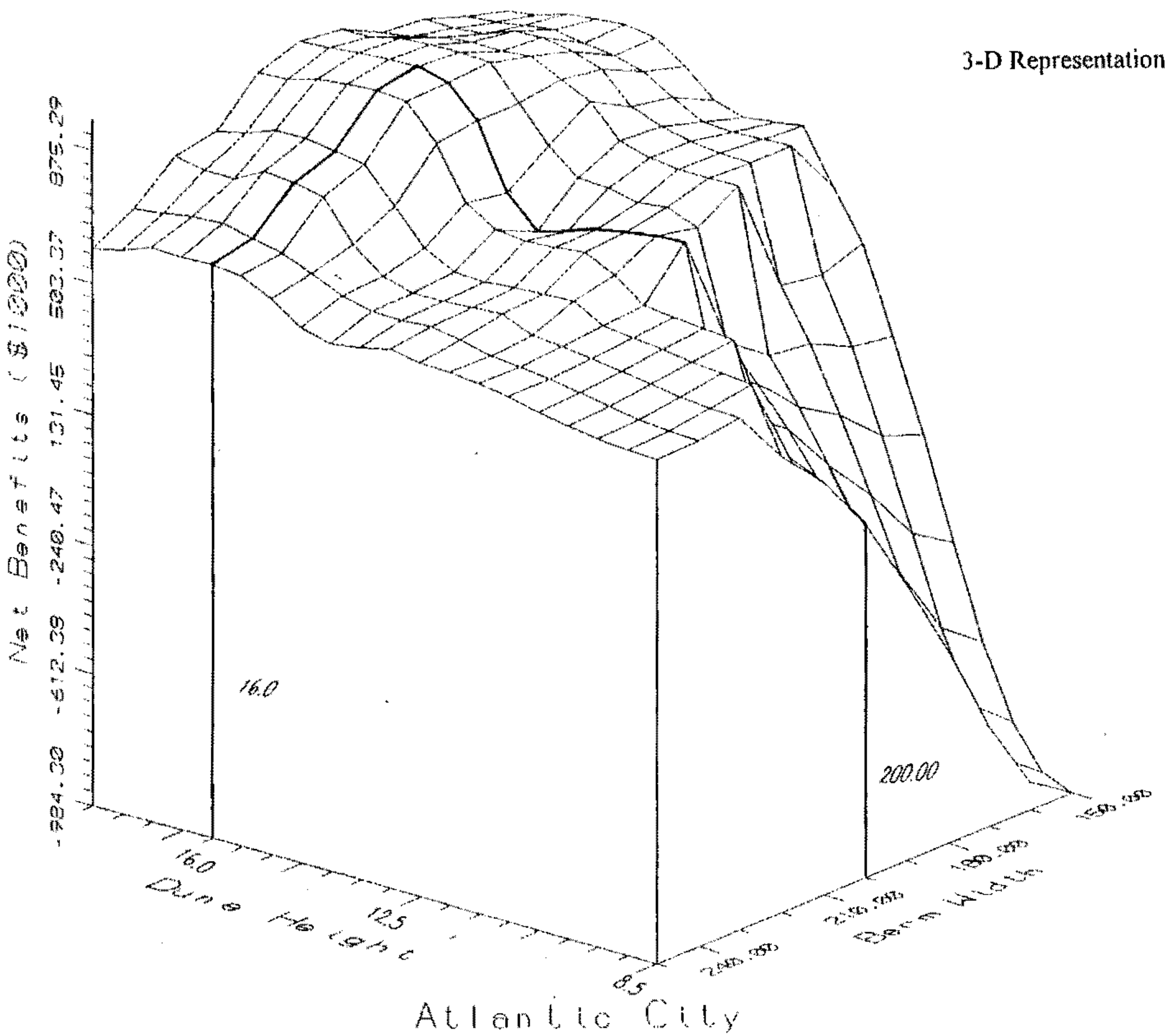
Atlantic City Oceanfront Benefit/Cost Matrix Average Annual Benefits and Costs for With Project Alternatives (Oct. 1995 Price Level)				
		150' BERM	200' BERM	250' BERM
		ALT. CW		
NO DUNE	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$2,091,249 $3,075,593 0.68 ($984,344)		
		ALT. CX	ALT. DX	
+14' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$3,796,954 $3,127,149 1.21 $669,806	$3,893,330 $3,301,274 1.18 $592,056	
		ALT. CY	**ALT. DY**	ALT. EY
+16' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$4,048,421 $3,216,410 1.26 $832,011	**$4,356,451** **$3,399,153** **1.28** **$957,298**	$4,522,078 $3,873,690 1.17 $648,388
			ALT. DZ	
+18' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS		$4,474,417 $3,541,844 1.26 $932,573	

438. It can be seen from Table 40 that costs to increase the berm width rise faster than benefits between the 200 ft berm and the 250 ft berm. Likewise, benefits with the 18 ft dune do not outweigh costs associated with the larger dune.

439. The NED plan is that plan which maximizes net benefits. Figure 38 is a 3 dimensional representation of net benefits for the various Atlantic City oceanfront alternatives. It can be seen that by changing the dimensions of either berm width of dune height away from the optimum plan (200 foot berm/16 foot dune), net benefits decrease.

Figure 38

3-D Representation of Net Benefits



440. The beachfill design alternatives for Ventnor, Margate and Longport will reduce storm damage by reducing profile recession, flooding incurred due to high levels of ocean storm water elevations, and wave run-up and direct wave impacts. Damages for the with project alternatives were calculated using the same methodologies and databases as previously detailed in the without project conditions. The benefits for any given project are the difference between without project damages and with project damages. The storm damage reduction benefits (including emergency costs) are shown for all Ventnor, Margate and Longport alternatives in Table 41.

Table 41

Ventnor, Margate, Longport
Storm Damage Reduction By Alternative
(March 1994 Price Level)

Alt.	Berm	Dune	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
AV	75	+12.5	$6,210,000	$2,833,834	$3,376,166	51%
BX	100	+14	$6,210,000	$2,219,820	$3,990,180	61%
CW	150	Existing	$6,210,000	$4,431,060	$1,778,940	25%
CX	150	+14	$6,210,000	$2,157,020	$4,052,980	62%
CY	150	+16	$6,210,000	$1,643,870	$4,566,130	70%
DX	200	+14	$6,210,000	$2,026,430	$4,183,570	64%
DY	200	+16	$6,210,000	$1,542,290	$4,667,710	72%

441. OPTIMIZATION OF VENTNOR, MARGATE AND LONGPORT. Optimization of the alternatives is based on storm damage reduction which is the priority benefit category. During this analysis of net benefits, figure were adjusted to the October 1995 price level. Initial fill and nourishment costs for the various project alternatives are annualized for comparison to the average annual benefits for a specific project alternative. Recreation and other incidental benefits were not used in the optimization procedure. Initial construction, periodic nourishment, and major rehabilitation costs are annualized over a 50 year project life at 7⅝%. The average annual costs are subtracted from average annual benefits to calculate net benefits and select the optimal plan which maximizes net benefits. Included in Table 42 are the average annual benefits and costs, the net benefits and benefit-cost ratio for storm damage reduction and reduced maintenance benefits. Plan BX with a 100' berm and a dune at +14 NGVD is the optimal plan for Ventnor, Margate, Longport.

Table 42

Ventnor, Margate, Longport Benefit/Cost Matrix Average Annual Benefits and Costs for With Project Alternatives (Oct. 1995 Price Level)					
		75' BERM	100' BERM	150' BERM	200' BERM
				ALT. CW	
NO DUNE	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS			$1,832,479 $4,028,980 0.45 ($2,196,501)	
		ALT. AV			
+12.5' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS	$3,477,775 $3,271,404 1.06 $206,370			
			ALT. BX	ALT. CX	ALT. DX
+14' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS		**$4,110,268** **$3,517,916** **1.17** **$592,352**	$4,174,958 $4,313,241 0.97 ($138,283)	$4,309,478 $4,984,092 0.86 ($674,614)
				ALT. CY	ALT. DY
+16' NGVD DUNE HEIGHT	AVERAGE ANNUAL BENEFITS AVERAGE ANNUAL COSTS BENEFIT-COST RATIO NET BENEFITS			$4,703,552 $4,407,449 1.07 $296,102	$4,808,189 $5,080,370 0.95 ($272,181)

Note: N/A denotes those alternatives which were not appropriate designs (see Table 36).

442. It can be seen from Table 42 that costs to increase the berm width rise faster than benefits between the 100 ft berm and the 150 ft berm. Likewise, the 16 ft dune provides less net benefits than the 14 ft dune.

443. Results of the hydraulic modeling indicated that dune height affects inundation and berm width affects erosion. This is a simplification, but was found to be generally true. Trends which were observed when interpreting the results of the storm damage analyses can be applied to the alternatives in question.

444. <u>12.5 ft dune/100 ft berm</u> - As seen in table 41, benefits increase ten percent from alternative AV

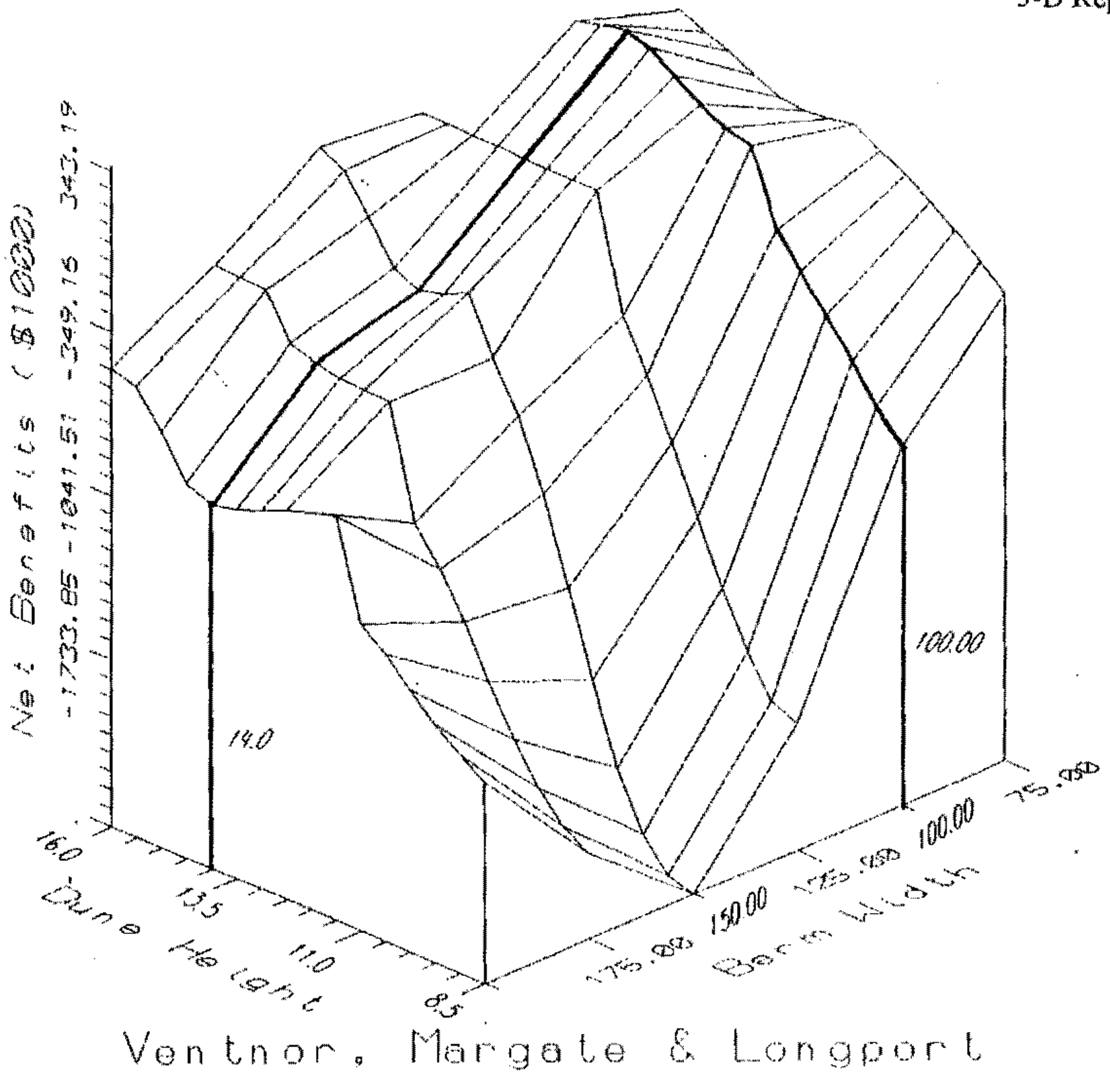
to BX. This increase is due almost solely to the wave-inundation damage mechanism associated with the dune height increase. The increase in berm width from 75 feet to 100 feet had almost no effect on the benefits. At the same time, costs went up only 7.5 percent, resulting in higher net benefits. Therefore it can be surmised that increasing the berm width to 100 ft while not increasing the dune height would result in, virtually the same benefits and higher costs, resulting in less net benefits.

445. <u>12.5 ft dune/150 ft berm</u> - As seen in table 41, benefits increase only one percent from alternative BX to CX. Of that increase, $67,500 is due to erosion and $61,680 is due to wave-inundation. The increase in berm width from 100 feet to 150 feet had a small overall effect on the benefits. At the same time, costs went up by 23 percent, resulting in greatly reduced net benefits. Therefore it can be surmised that increasing the berm width to 150 ft while not increasing the dune height will result in, virtually the same benefits and much higher costs, resulting in less net benefits.

446. The NED plan is that plan which maximizes net benefits. Figure 39 is a 3 dimensional representation of net benefits for the various Ventnor, Margate and Longport oceanfront alternatives. It can be seen that by changing the dimensions of either berm width of dune height away from the optimum plan (100 foot berm/14 foot dune), net benefits decrease.

Figure 39

3-D Representation of Net Benefits



447. GROIN ANALYSIS. Following the selection of the optimized beachfill alternative, groins were analyzed to determine whether the costs to construct them is offset by the savings due to the reduction in periodic nourishment. Coincident with this effort, periodic nourishment requirements based on past reports and historic shoreline change were compared with the results of GENESIS shoreline evolution modelling.

NUMERICAL MODELLING OF SHORELINE CHANGE

448. GENERAL. In recent years numerical shoreline change models have become an increasingly popular tool for investigating impacts of proposed coastal projects. Specifically, shoreline change models are ideally suited for tasks involving the analysis and evaluation of coastal projects with regard to the long-term fate of beachfills, renourishment cycles and coastal structures designed to enhance the longevity of placed beach fill material. As part of this Feasibility study, a shoreline change model has been developed which may be used for predicting relative future shoreline trends and responses along the Atlantic Ocean coastline of Absecon Island.

449. GENERALIZED MODEL FOR SIMULATING SHORELINE CHANGE (GENESIS). The shoreline change model used in this study is GENESIS, developed by the U.S. Army Corps of Engineers, Coastal Engineering Research Center (Hanson and Kraus, 1989; Gravens, Kraus and Hanson, 1991). The acronym GENESIS stands for <u>GENE</u>ralized Model for <u>SI</u>mulating <u>S</u>horeline Change and encompasses a group of programs developed for simulating wave-induced longshore transport and movement of the shoreline. GENESIS was developed to simulate long-term shoreline change on an open coast as produced by spatial and temporal changes in longshore transport (Hanson, 1987, 1989; Hanson and Kraus, 1989). Wave action is the mechanism producing longshore transport. In GENESIS, spatial and temporal differences in the transport rate may be caused by such diverse factors as irregular bottom bathymetry, wave diffraction behind structures, sources and sinks of sand, and structures such as seawalls or groins which constrain the transport.

450. <u>Capabilities and Limitations of GENESIS</u>. GENESIS is designed to describe long-term trends of the beach plan shape change under imposed wave conditions, boundary conditions, and constraints due to coastal structures. GENESIS works best in calculating shoreline response when the change will produce a long-term trend in shoreline movement, as it progresses from one equilibrium state toward another as a result of some significant perturbation. Shoreline change models are not applicable to simulating a randomly fluctuating beach system in which no shoreline movement trend is evident. GENESIS is not applicable to calculating shoreline change in the following situations which involve shoreline change unrelated to spatial differences in wave-induced longshore sand transport: beach change inside inlets or areas dominated by tidal currents, beach change produced by wind-generated currents, storm-induced beach erosion where cross-shore sediment processes dominate the beach evolution process (this type of beach evolution is best modelled using a cross-shore transport model such as SBEACH).

451. GENESIS is based on the one-contour-line beach evolution concept. It is assumed that the beach profile maintains a constant equilibrium profile shape. This implies that the bottom contours are parallel and the entire profile is translated seaward or landward for an accreting or eroding

shoreline, respectively. With this assumption, it is only necessary to consider the movement of one contour line. For this study, the mean high water (MHW) contour was chosen.

452. Input Data Requirements. There are two dominant physical data types that must be assembled for input to GENESIS; shoreline position data and wave data.

453. U.S. Army Corps of Engineers LRP survey lines along the project area were analyzed to determine the average berm height and the depth of closure. These parameters define the vertical limits of the control volume within which longshore sand transport takes place. Multiplying this vertical range by the shoreline length and the shoreline change (advance/retreat) allows the conversion of shoreline change data to volumetric change data. As detailed earlier, GENESIS does not model the offshore profile response, but assumes that the beach profile retains the same shape while moving landward and seaward. However, profile information is needed to determine the location of breaking waves alongshore and depths at the offshore tips of structures, and to calculate an average nearshore bottom slope for use in the longshore transport equation. To develop this profile information, GENESIS requires the "effective grain size" (corresponding to the equilibrium profile) to be input.

454. SIMULATION OF LONG-TERM SHORELINE CHANGE. A sediment budget was developed for the Atlantic Ocean coastline of New Jersey ranging from North Brigantine Island to Ocean City. The sources, sinks and volumetric rates of sand moving into and out of the region were investigated (see earlier section "Brigantine Inlet to Great Egg Harbor Inlet Sediment Budget" for further detail). The objective of the budget study was to account for the gain or loss of sediment through time by a study of the various factors that influence sediment erosion, transportation and deposition in the study area.

455. Development of a Wave Climate. The calibration/verification time period modelled extended from October 7, 1986 to March 6, 1993, based upon the available shoreline position information (see next section). A wave hindcast in 10 meters of water extending from November 1, 1987 to October 31, 1993 was used as a basis for developing the wave climate. The hindcast was based on WIS Station 68 data which had been transformed in from deep water using the SHALWAVE routine, which considers real bathymetry in its computational routine. As the period from October 7, 1986 to October 31, 1987 was lacking from the available hindcast, steps were taken to fill this gap, based on analysis of the hindcast and knowledge of the actual wave conditions during that time. Due to their generally similar mild characteristics, the first three years of data in the hindcast (November 1, 1987 to October 31, 1990) were vector averaged to develop a wave data record to be substituted into the period of November 1, 1986 to October 31, 1987. The portion of the vector averaged record from October 7, 1987 to October 31, 1987 was also substituted into the period of October 7, 1986 to October 31, 1986.

456. GENESIS CALIBRATION AND VERIFICATION STRATEGY. Mean high water shoreline position information from 1986, 1991 and 1993 was available for use in calibration and verification of the GENESIS model. The shoreline data is specified relative to the project baseline. The 1986 shoreline position was taken from the Leatherman shoreline mapping project and occurred in October of that year. The 1991 shoreline position was digitized from aerial photographs taken on March 7th. The 1993 shoreline was taken from planimetric maps of April of that year. As only the 1991 shoreline

had a day of the month specified, and GENESIS requires that a year, month and day be specified, the 1986 and 1993 shorelines were also assumed to occur on the 7th of the month.

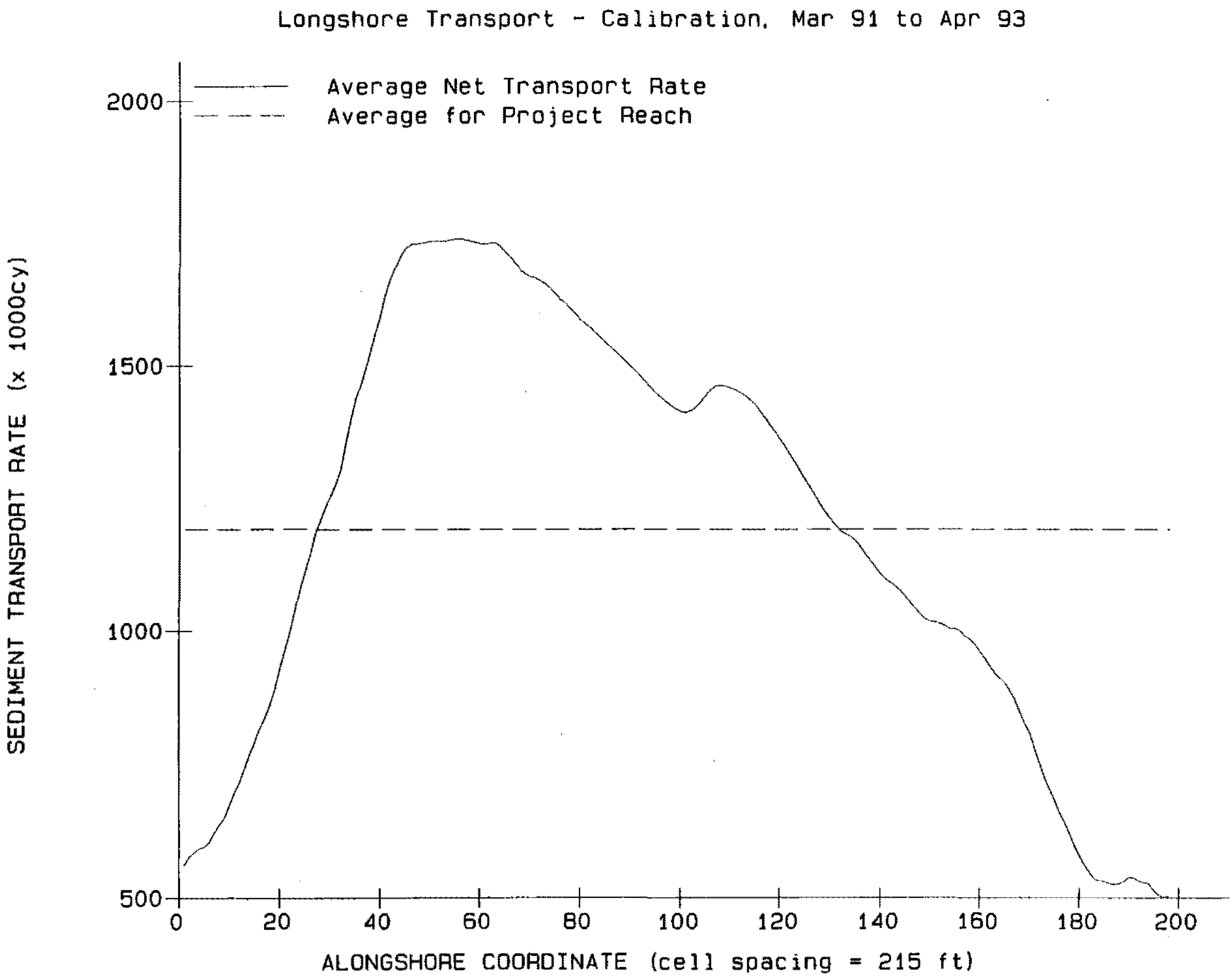
457. The GENESIS grid divides the Atlantic Ocean shoreline of Absecon Island into 198 compartments, each measuring 215 feet. The overall grid extends from the Oriental Avenue jetty in Atlantic City to the terminal groin at 11th Street in Longport. In developing the grid, cell dimensions were kept as small as possible to allow for resolution of the extensive groin fields in Atlantic City and Longport, as GENESIS requires two cells between groins to be modelled.

458. The RCPWAVE routine was run on the hindcast wave field to develop height and angle transformation parameters to bring the waves from 10 meter depth to a location landward of significant offshore bathymetry but prior to breaking, in this case 18 feet of water. The RCPWAVE grid covers the same stretch of shoreline as the GENESIS grid, dividing it into 33 compartments, each measuring 1290 feet, for a shoreline resolution of one-sixth that of the GENESIS grid. During model calibration the GENESIS model was run using its internal wave transformation model and using the external RCPWAVE wave transformation model, for comparison of results.

459. Model Calibration. Based upon the dates of the available shoreline position data detailed previously, there was a choice of calibrating the GENESIS model from October 7, 1986 to March 7, 1991, or from March 7, 1991 to April 7, 1993. The latter interval was chosen for two reasons: wave data for the entire period between the two sampled shorelines was available from the original hindcast, and, the two shorelines were measured at the same time of year. Thus the shoreline position data and wave record for the period from March 7, 1991 to April 7, 1993 was used in the calibration effort, and the shoreline position data and wave record for the period from October 7, 1986 to March 7, 1991 was used in the verification effort. The natural shoreline change occurring between March 7, 1991 and April 7, 1993 can be seen in the appendix.

460. Several parameters were varied and tested during the model development, chief among them the permeability of existing coastal structures, wave sheltering angles, wave transformation methods, and the model's internal longshore transport rate scaling variables.

461. Groins are specified in the model by their longshore location as referenced to the GENESIS grid, the distance of their offshore tip from the model baseline, and their permeability, specified as a value between 0.0 and 1.0. An impermeable groin is assigned a value of 0.0, and the model only allows sand to pass over it or around the seaward end. At the opposite end of the spectrum, a groin assigned a permeability of 1.0 is treated by the model as being transparent, and has no effect on longshore transport. It was found that adjusting the value of permeability of one groin could affect large changes in the shoreline evolution in the immediate area of that groin, but that changes over a larger area required several groins in tandem to be set to one of the extremes of the permeability range. This is obviously not the case in nature due to the wide variety of construction types and conditions detailed in the structure inventory. As GENESIS does not take into account the inlet processes which occur at both ends of the study area, and the groin fields are located at the ends of the study area, it was decided to determine which "k" values produced the best shoreline agreement in the interior areas of the island (Ventnor and Margate) and then adjust groin permeabilities to replicate the shoreline at the ends of the study area. Also during model development, wave sheltering



Longshore Transport - Calibration, Mar 91 to Apr 93
Average Net Transport Rate
Average for Project Reach
SEDIMENT TRANSPORT RATE (x 1000cy)
2000
1500
1000
500
0
20
40
60
80
100
120
140
160
180
200
ALONGSHORE COORDINATE (cell spacing = 215 ft)

Figure 40

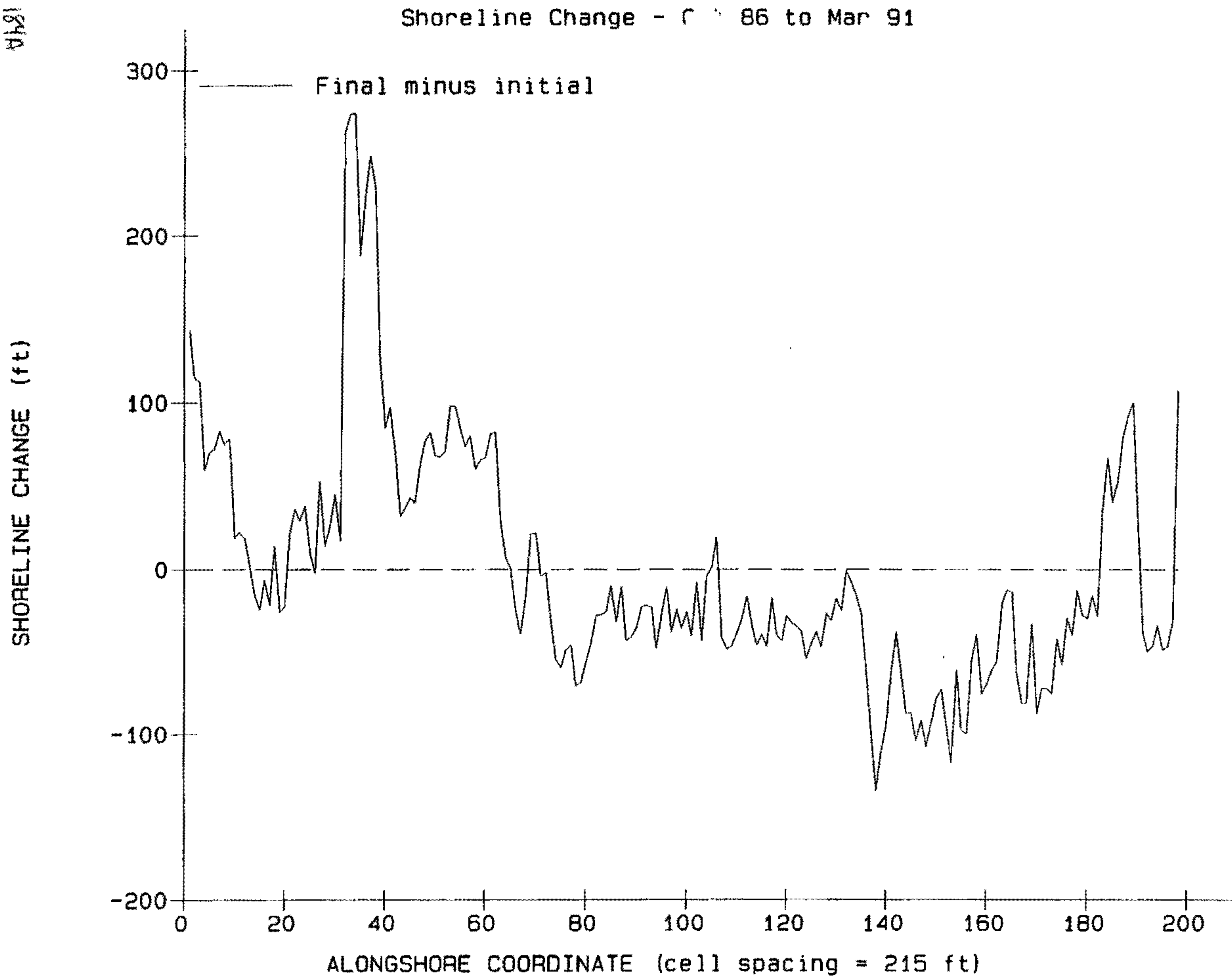

Shoreline Change - [illegible] 86 to Mar 91
Final minus initial
SHORELINE CHANGE (ft)
300
200
100
0
-100
-200
0
20
40
60
80
100
120
140
160
180
200
ALONGSHORE COORDINATE (cell spacing = 215 ft)

Figure 41

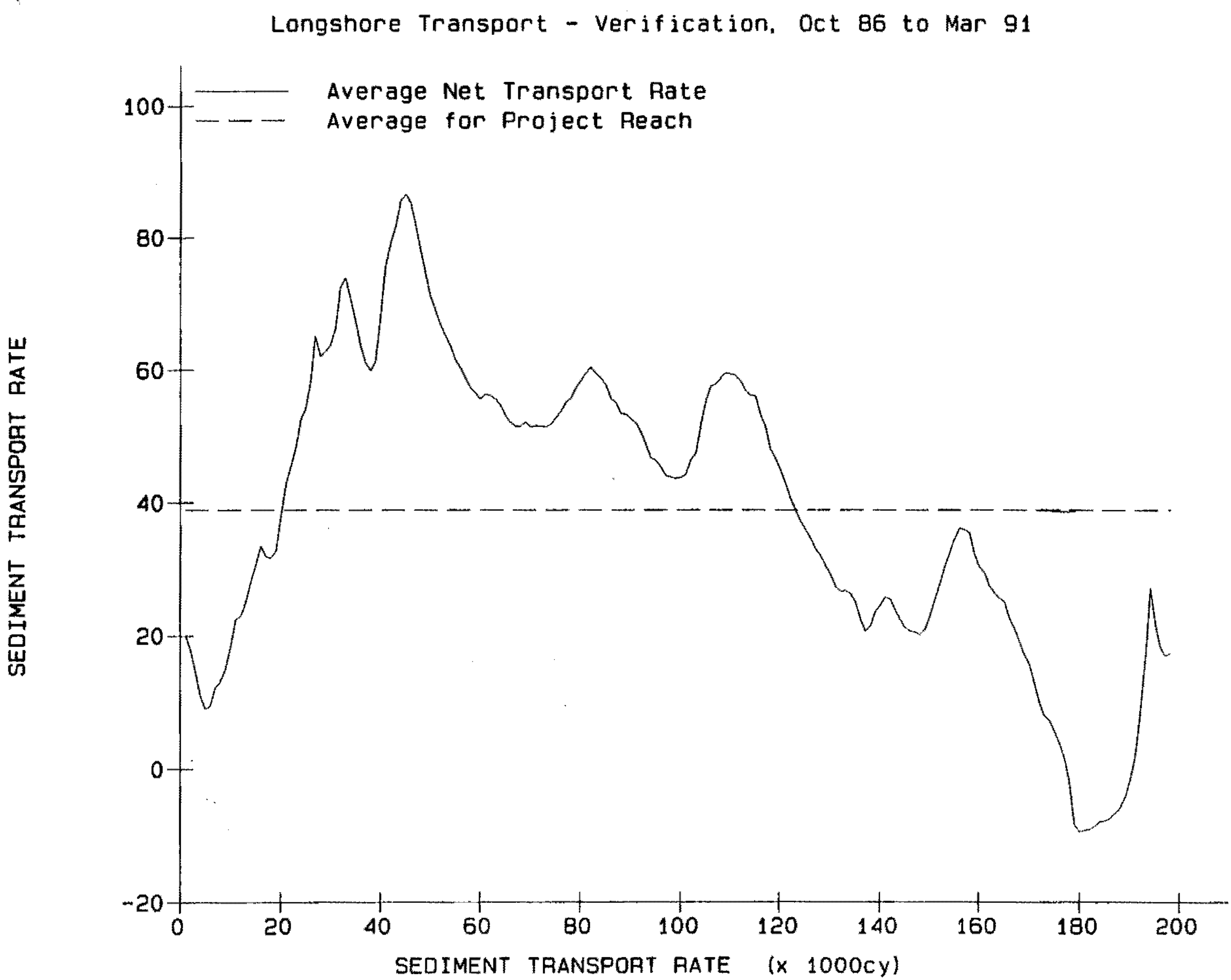

Longshore Transport - Verification, Oct 86 to Mar 91
Average Net Transport Rate
Average for Project Reach
SEDIMENT TRANSPORT RATE
100
80
60
40
20
0
-20
0
20
40
60
80
100
120
140
160
180
200
SEDIMENT TRANSPORT RATE (x 1000cy)

Figure 42

465. The verification time period takes place immediately after the 1,000,000 cy fill in Atlantic City in 1986. As the natural shoreline evolution over this period shows, the southern and northern ends of the Atlantic City groin field accrete, while there is a slight erosion in the area between Garden Pier and Steel Pier, which is a suspected nodal zone. The verification of the calibrated model indicates an average longshore transport rate of 40,000 cy/yr (Figure 42), which is lower than previous predictions, but is expected, as this time period was known to have a mild wave climate.

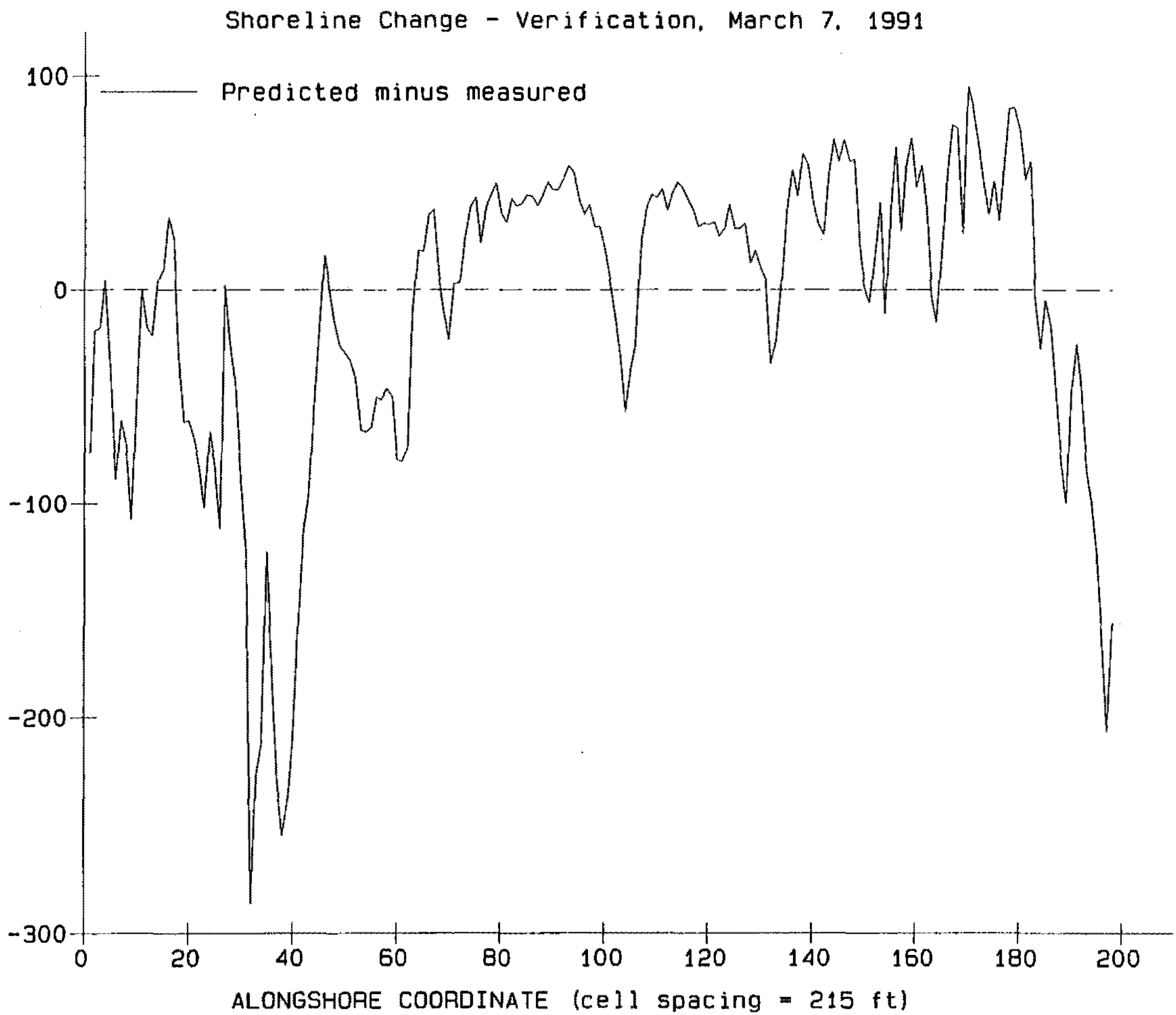
466. The difference between the GENESIS predicted April 7, 1993 shoreline, and the measured April 7, 1993 shoreline is shown in Figure 43. Although the model has difficulty in several locations reproducing the naturally evolving shoreline, it does simulate the large-scale trends of sediment transport occurring over the island. Thus it was decided to proceed to a with project analysis to investigate relative changes in shoreline evolution for different time intervals.

467. ANALYSIS OF THE OPTIMIZED BEACHFILL DESIGN. To develop estimates of renourishment rates for the selected plan for various cycle lengths, the calibrated model conditions are applied to the base year shoreline of the constructed project. Wave record lengths of one year to ten years in duration are applied to the base year shoreline to allow for economic optimization of the renourishment cycle.

468. The one deviation from the calibrated model is that in the analysis of the future conditions, the shoreline accretion due to mechanical dune-building operations is removed from the model as it is assumed that all beach fill activities will be a function of the chosen periodic renourishment cycle.

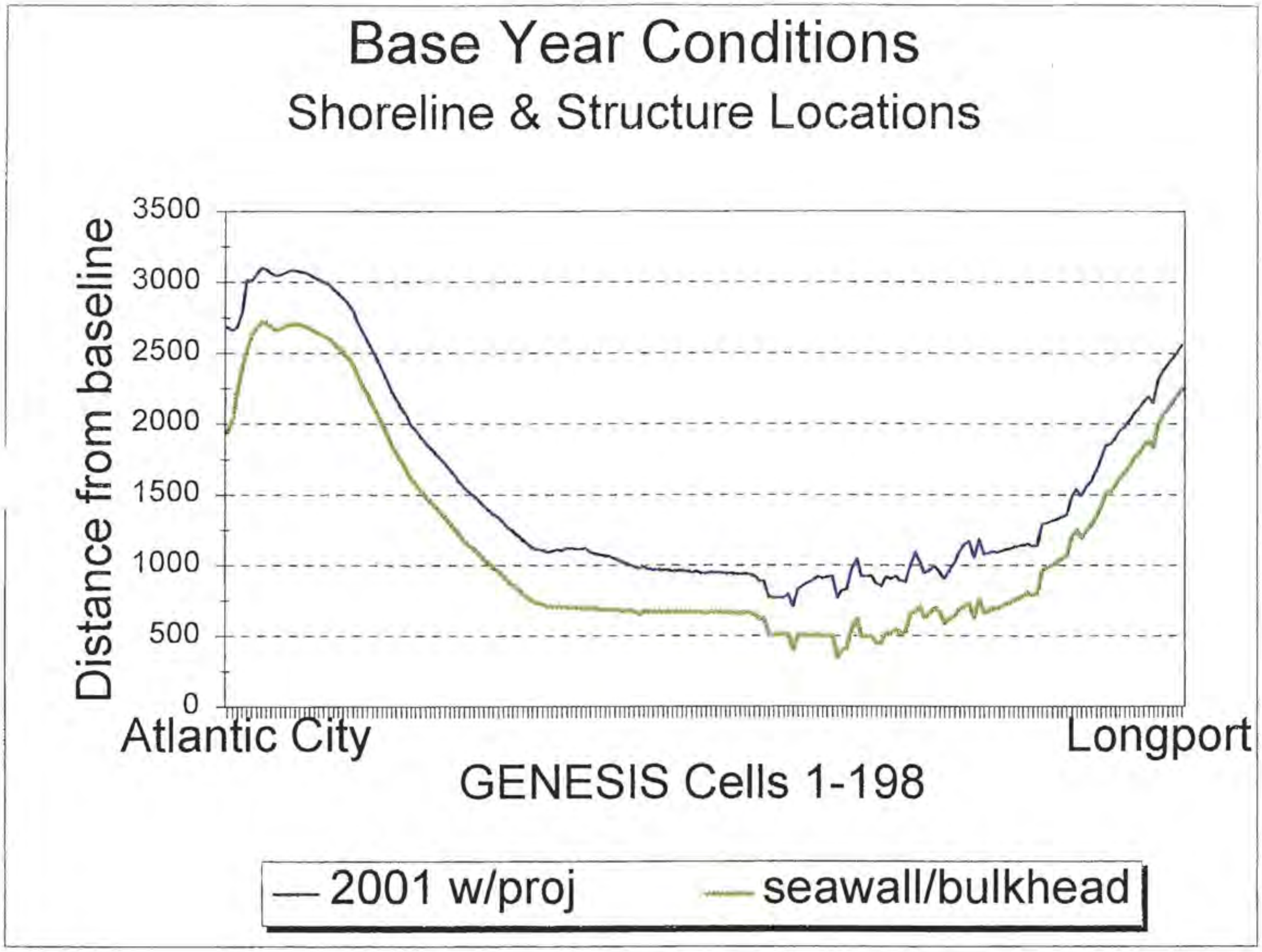
469. Base Year Shoreline. The mean high water shoreline position data based on the design template were used as a starting point in developing the base year shoreline which will occur in the year 2001. These data were then checked against the 1993 measured shoreline position data. Two reaches were discovered where the 1993 shoreline was seaward of the design template shoreline. In these areas (GENESIS cells 1-3 and 68-87) the 1993 shoreline position data were substituted for the design template shoreline position data. Both of these areas are outside of the area of Atlantic City (GENESIS cells 8-64) in which long-term shoreline erosion was indicated. Fill will still need to be placed in these areas to raise the berm elevation and construct the dune. The adjusted base year shoreline is shown in Figure 44.

470. Wave Record Development. It was necessary to determine an average condition wave record to apply to the base year shoreline to predict renourishment quantities. To accomplish this, the hindcast wave record was split into six one-year segments. For each year, the -90 to 90 degree directional spectrum was divided into 18 angle bands, each of 10 degree width. For each angle band in a given year, the number of wave occurrences and the percentage of the spectral energy in that angle band was computed. For a given angle band, the number of occurrences for each of the six years were averaged, as were the percentages of the spectral energy. Standard deviations were also computed. If the number of occurrences or the percentage of spectral energy in an angle band in a given year fell within plus or minus one standard deviation of the average for that angle band, it was considered a hit. Values outside of a one standard deviation range of the average were considered to be a miss. The number of hits for each year was then totalled, with the year containing the most hits being considered as the most representative year of the wave record.



Shoreline Change - Verification, March 7, 1991
Predicted minus measured
SHORELINE CHANGE (ft)
100
0
-100
-200
-300
0
20
40
60
80
100
120
140
160
180
200
ALONGSHORE COORDINATE (cell spacing = 215 ft)

Figure 43



Base Year Conditions
Shoreline & Structure Locations
Distance from baseline
3500
3000
2500
2000
1500
1000
500
0
Atlantic City
Longport
GENESIS Cells 1-198
2001 w/proj
seawall/bulkhead

Figure 44

471. From this analysis it was determined that the second year of the hindcast wave record, November 1, 1988 to October 31, 1989, was the most representative year of the six year hindcast. Thus in the with project analysis, this year's wave record was appended, end-to-end, as many as ten times to manufacture the desired lengths of wave record to be applied to the base year shoreline conditions.

472. Model Output. As the shorelines generated by the model are prone to local spikes, it was decided to first analyze the model predictions as a function of the cumulative volumetric change within each municipality's incorporated boundary. Table 43 shows that Atlantic City and Longport eroded each year, and Ventnor and Margate accreted each year. Logically, the accretion in Ventnor and Margate cannot continue indefinitely. Possible explanations of this phenomenon are: the accretion may stop or reverse if wave records of longer than ten years duration were applied to the base year conditions; representing a long period by repeating a one year representative wave record does not account for the variability of wave climates seen in nature; and one possible sink, offshore loss, is not represented by the model. If these numbers were to be used to recommend a renourishment cycle, only the losses in Atlantic City and Longport should be considered. The amount of fill needed to renourish the Atlantic City and Longport shorelines should not be reduced by the amount of accretion occurring in Ventnor and Margate. However, the values reported by the model based on the predicted shoreline were roughly 15 to 20% of the historical estimates of renourishment requirements (Table 43).

473. When the model predicted shorelines are examined on a cell by cell basis, it is seen that each municipality has areas of erosion and areas of accretion. Thus, it was deemed as too broad a generalization to state that Ventnor and Margate continually accrete and do not require renourishment. Investigating the minimum (farthest landward retreat) shoreline computed by GENESIS allows a more conservative view of the model output. In this scenario, shown in Table 44, the predicted volumetric changes within municipal boundaries are in much better agreement with the historical predictions.

474. GROINS. Additional groins were added to the base year model to investigate if their sand trapping capability could reduce the required renourishment rates sufficiently to offset their cost. The area to the south of the existing Atlantic City groin field was the site of this investigation, due to the impact of the existing groins and local changes in shoreline orientation. In an attempt to smooth and stabilize the shoreline in this area, 100 feet was removed from the seaward end of the groin at Martin Luther King Boulevard (GENESIS cell 32), and four groins were added to the south: Ohio Avenue (GENESIS cell 35) extending 300 feet seaward of the MHW shoreline, Georgia Avenue (GENESIS cell 43) extending 200 feet seaward of the MHW shoreline, Texas Avenue (GENESIS cell) extending 100 feet seaward of the MHW shoreline, and Brighton Avenue (GENESIS cell 52) also extending 100 feet seaward of the MHW shoreline.

475. The model results indicate that any benefit due to the amount of sand trapped by the groins will be offset due to a roughly equal amount of starvation occurring immediately downdrift of the groin field. The presence of the additional groins does not appreciably affect change in the renourishment rate predictions outside of Atlantic City. Table 45 compares the Atlantic City renourishment rate predictions for the with project scenario with and without the additional groins. The permeability

Absecon Island Volumetric Change
Predicted vs. Historical Rates
(cubic yards)

Cycle	Atlantic City	Ventnor	Margate	Longport	TOTAL	HISTORICAL
1 year	-25,000	15,000	20,000	-25,000	50,000	400,000
2 year	-40,000	45,000	30,000	-75,000	125,000	800,000
3 year	-55,000	65,000	40,000	-130,000	185,000	1,200,000
4 year	-70,000	85,000	55,000	-185,000	255,000	1,600,000
5 year	-85,000	100,000	75,000	-245,000	330,000	2,000,000
6 year	-100,000	110,000	100,000	-310,000	410,000	2,400,000
7 year	-115,000	125,000	120,000	-375,000	490,000	2,800,000
8 year	-125,000	135,000	145,000	-430,000	555,000	3,200,000
9 year	-145,000	145,000	170,000	-485,000	630,000	3,600,000
10 year	-160,000	160,000	200,000	-535,000	695,000	4,000,000

"Total" refers to the volume of sand lost from the Atlantic Ocean coastline of Atlantic City and Longport

"Historical" refers to the historical estimate based on long-term erosion, storms and sea-level rise for the Atlantic Ocean coastline of Absecon Island

Table 43

ATLANTIC CITY NOURISHMENT REQUIREMENTS
WITH AND WITHOUT ADDITIONAL GROINS

Cycle	w/o Groins	w/ Groins	Volume Saved
1 year	260,000	270,000	(10,000)
2 year	330,000	350,000	(20,000)
3 year	390,000	400,000	(10,000)
4 year	440,000	450,000	(10,000)
5 year	490,000	490,000	0
6 year	540,000	520,000	20,000
7 year	590,000	560,000	30,000
8 year	630,000	590,000	40,000
9 year	680,000	620,000	60,000
10 year	730,000	650,000	80,000

Table 45

value assigned to the new groins was consistent with values assigned to existing groins in the calibrated model. As newly constructed groins may be less permeable, a lower permeability value was assigned to the new groins, and the model was run again. The increased amount of sand trapped by the groins was offset by an increased amount of starvation downstream of the groin field, thus it was concluded that new groin construction for the purpose of lowering the required renourishment rates was not economically justified.

476. RENOURISHMENT RATES. As the duration of the renourishment cycle is increased, the incremental quantity required as predicted by the model lessens. In addition, as the total quantity increases, the unit price decreases. Thus the annualized cost of the fill material continually decreases as the renourishment interval is increased. Also, with the increase in the duration of the renourishment cycle comes a corresponding decrease in the annualized cost of dredge mobilization and demobilization. The annualized cost of the engineering and surveying work required for the renourishment operation also decreases as the renourishment interval is increased. With all of the costs associated with renourishment operations decreasing as the renourishment interval is increased, economic optimization will occur at the longest interval for which data is provided, in this case a ten year interval.

477. However, this economic analysis does not take into account the risk of a large storm occurring during the interval between renourishment operations nor the risk of higher energy year (one outside the envelope of represented by the sample wave record) occurring. These risks grow with every year the renourishment cycle is increased. This method of analysis will yield a result based upon the largest storm which occurred during the wave record used. However, there is a certain annual probability of occurrence of all storms larger than the lowest frequency storm contained within the wave record. Each year's predicted renourishment rate should not be viewed as a single number, but as an envelope containing a specified percentage of all possible shorelines. At the present time, there is no generally accepted method to quantify this risk and apply it to the economic analysis, but common sense dictates that the increase in this risk would diminish returns as the renourishment cycle is lengthened.

478. Sorensen, Weggel and Douglass (1989) studied the most recent Atlantic City beach fill in 1986 and Everts et al. (1974) studied the 1963 and 1970 fills. Everts et al. (1974) concluded that most sand is lost to the offshore region during the period from September through March, thus placing the fill material in the spring will maximize its residence time on the beach face. Everts et al. (1974) also found that the rate of loss of fill material is proportional to the quantity placed at one time, and thus recommend placing smaller volumes on a more frequent basis to maximize overall residence time. Sorensen, Weggel and Douglass (1989) also recommended frequent placement of small volumes, with the renourishment cycle in the two to four year range.

479. Thus, based on model results, historical predictions, and past experiences in Atlantic City and elsewhere, a three year renourishment cycle, with a total quantity of 1,190,000 cy for the Absecon Island shoreline is recommended. Further, it is recommended that the fill be placed in the spring to maximize residence time.

480. GROIN FIELD. Reduced nourishment rates within Atlantic City due to the proposed groin

field are shown in table 45. If this groin field were built in Atlantic City as part of the selected plan, the annualized cost would be $335,003, while there would be no savings (benefits) in reduced periodic nourishment. Therefore, the placement of a groin field in combination with Plan DY at Atlantic City is not justified. Similarly, the groin field option proposed in Cycle 2 for Longport is also not justified.

481. EXTENSION OF THE LONGPORT TERMINAL GROIN. The remaining groin option from the cycle 2 analysis was the extension of the Longport terminal groin as a way to decrease end losses at the southern terminus of the project. This option must be looked at in relationship to the borrow areas, other projects in the vicinity and potential downdrift impacts.

482. Design Constraints. The outer end of a groin designed to protect a beachfill should be placed where the designed beach slope intersects the existing bottom. Groins placed at the southern terminus of New Jersey's barrier islands are known to trap sediment to such a degree that starvation of the downdrift beach can occur. Also, groins that extend seaward of the breaker zone may force sand to flow too far offshore to be returned to the downdrift beaches, or in this case, the Great Egg Harbor Inlet ebb shoal.

483. Extending the Longport terminal groin would likely impact the sediment budget in Great Egg Harbor Inlet and therefore impact both the Longport borrow area identified in this study and the borrow area currently being used for the Peck Beach/Ocean City Federal project.

484. Longport Borrow area Considerations. During all three time periods analyzed in the sediment budget, the Great Egg Harbor Inlet control volume experienced shoal growth of varying rates. During the period from 1986 to 1993, growth of the Great Egg Harbor Inlet shoals was approximately 200,000 cy/yr. A combination of extending the Longport terminal groin and borrowing from the Longport borrow area would produce a range of negative impacts which would likely exceed any possible benefits of reduced nourishment quantities.

485. CYCLE 3 SUMMARY. Tables 35, 40 and 42 identify the optimized plans for the study area. Included in these tables are the average annual benefits and costs, the net benefits and benefit-cost ratio for storm damage reduction. Plan DY, which provides a 200 ft. berm and a dune with an elevation of +16 ft. NGVD is the optimal design in Atlantic City, while the optimal beachfill design in Ventnor, Margate & Longport is Plan BX which provides a berm width of 100 ft. and dune with an elevation of +14 ft NGVD. The bulkhead design was the optimum plan for the inlet frontage of Atlantic City.

486. The optimized plans are futher detailed in the following Selected Plan chapter.

SELECTED PLAN

IDENTIFICATION OF THE NED PLAN

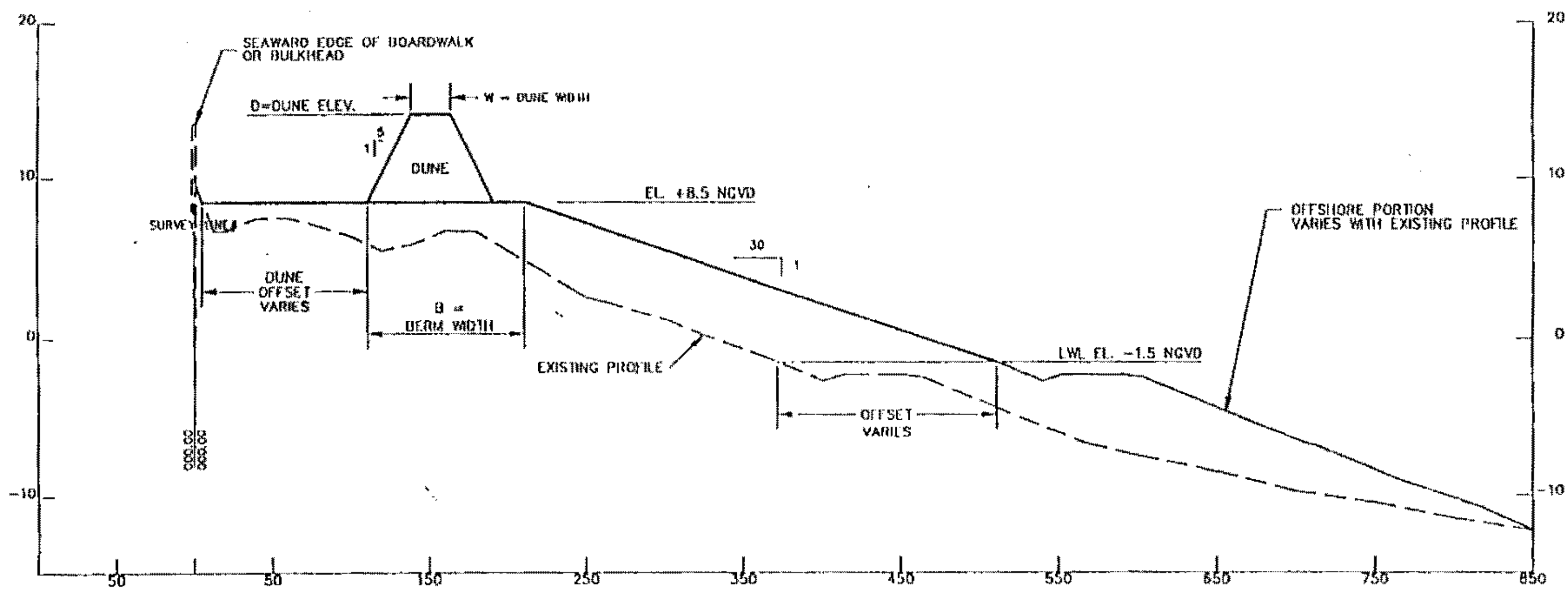
487. The National Economic Development (NED) Plan is defined as that plan which maximizes beneficial contributions to the Nation while meeting planning objectives. Most of the beachfill plans considered meet the planning objectives in that they provide a degree of storm damage protection which is greater than the cost of implementation. The NED plan for the oceanfront of Atlantic City is beachfill with a berm width of 200 ft. and a dune with an elevation of +16 ft NGVD and for Ventnor, Margate and Longport the NED plan is beachfill with a 100 ft. berm width and dune with an elevation of +14 ft NGVD. The NED plan for the inlet frontage of Atlantic City is to construct two bulkheads which tie into the existing structure. These plans were chosen because they provided the maximum net storm damage reduction benefits.

488. The proposed project does not include fill on privately owned shores or on lands behind erosion control lines.

489. DESCRIPTION OF THE SELECTED PLAN. The design of the selected plan is complete and is consistent with Corps criteria as described in the Shore Protection Manual, CETNs and accepted engineering practice. Additional design work (ie. a Design Memorandum) is not needed with the exception of geotechnical sampling which can be completed concurrent with the development of plans and specifications. The following section describes the selected plan for the study area.

490. Absecon Island Oceanfront. The selected plan for the Absecon Island ocean frontage is a beachfill restoration. In Atlantic City, the beachfill will consist of a 200' wide berm with a top elevation of +8.5 NGVD. A dune with a top elevation of +16 NGVD, top width of 25', and side slopes of 1V:5H will also be constructed, with the landward toe of the dune located 25' seaward of the seaward edge of the boardwalk. In Ventnor, Margate, and Longport the beachfill will have a 100' wide berm with a top elevation of +8.5 NGVD. Dunes will also be constructed to a top elevation of +14 NGVD, with a 25' top width, and side slopes of 1V:5H. The initial beachfill for the entire study area oceanfront will require a total volume of 6,174,013 cy of sand placed over a total length of 42,825 linear feet. The fill volume includes initial design fill requirements plus advanced nourishment. Periodic nourishment of 1,666,000 cy would be placed every 3 years. The beachfill will be transitioned from a 200' berm to a 100' berm between Atlantic City and Ventnor over a distance of 1000'.

491. Beach Access. The beach access strategy includes natural beach walkover paths, up and over the dunes at a skewed angle and delineated by sand fencing. The sponsor is responsible for maintaining the access ways by replacing fencing as needed, and providing additional sand fill if the access way degrades upon the design dimensions of the dune template. These walkovers would be strategically placed at most street ends or other traffic areas. The final location and dimensions of these walkovers and access ways will be coordinated with the sponsor and local communities during the preparation of plans and specifications. These walkover paths are in addition to any existing structural walkover features currently in place.



ALTERNATIVE	BERM WIDTH B FT.	DUNE WIDTH W FT.	DUNE ELEV. D + FT. NGVD
A	75	15	12.5
BX	100	25	14
CW	150	--	—
CX	150	25	14
CY	150	25	16
DX	200	25	14
DY	200	25	16
DZ	200	25	18
EY	250	25	16

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NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY
ABSECON ISLAND STUDY AREA
CYCLE 3 BEACHFILL QUANTITIES
TYPICAL CROSS SECTION

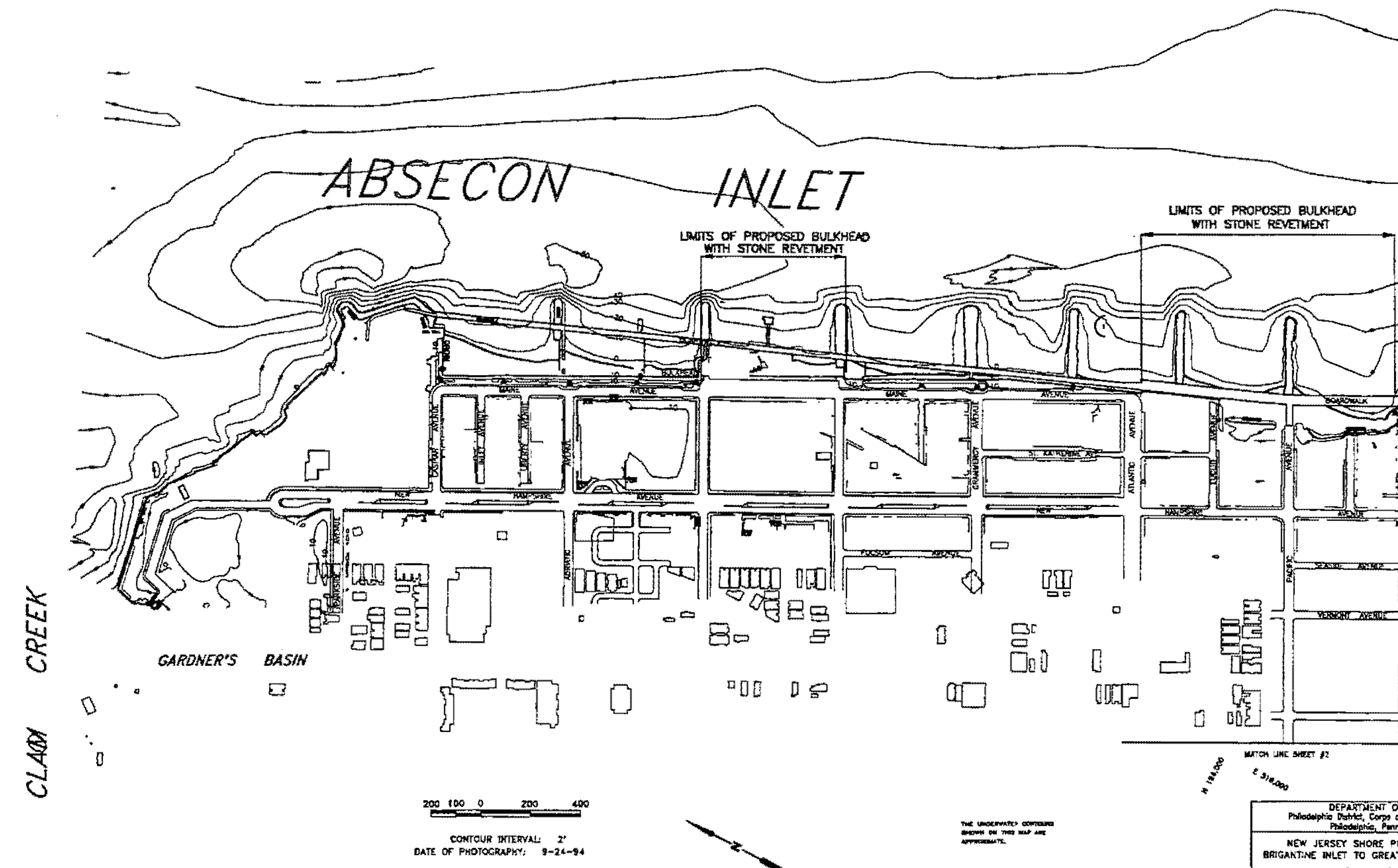
SCALE N.T.S. SHEET 5 OF 9

Figure 37

492. Vehicular access will be afforded at existing vehicular access points. These areas will be strengthened by rollup articulated pressure treated timber matting. These areas will also provide handicapped access as well. The final location and number of vehicular and or handicapped access points will be further coordinated with the communities during the development of plans and specifications.

493. The local communities may have special, site specific requirements for beach access appurtenances which may require the construction of additional, or modification of proposed access paths. This is conditionally acceptable with the COE as long as the access plans are fully coordinated with the COE to ensure no loss of project integrity, and with NJDEP for adherence to State coastal zone regulations.

494. The plan also includes the planting of 91 acres of dune grass and the erection of 63,675 linear feet of sand fence. Survey cross sections used to develop the selected plan beachfill volumes are presented in Appendix A. Annual operation and maintenance for the dune and dune crossovers is estimated to be $32,750. [The selected plan layout is shown in figures 45 through 53].



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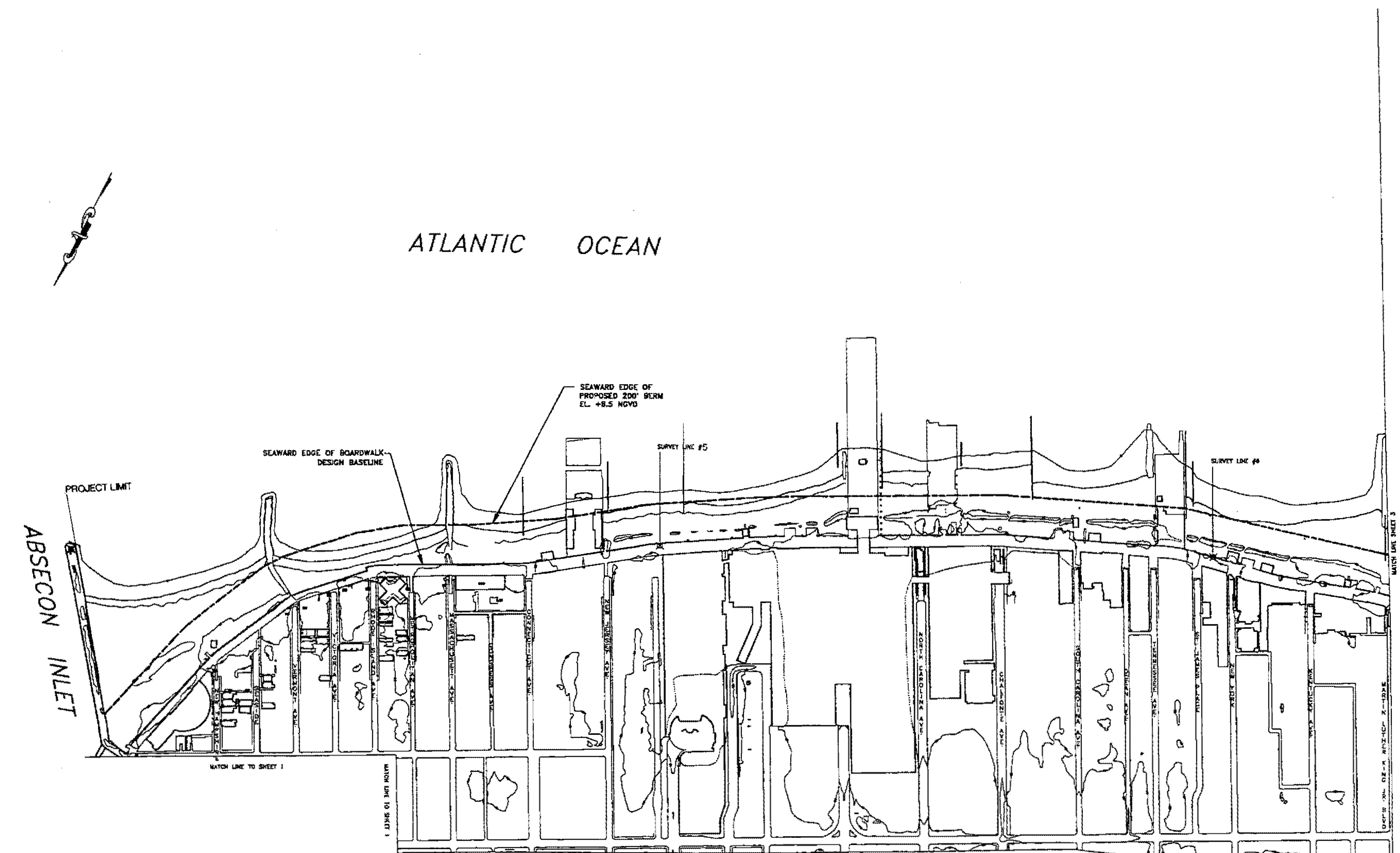
NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET

FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA
SELECTED PLAN

SHEET 1 OF 8



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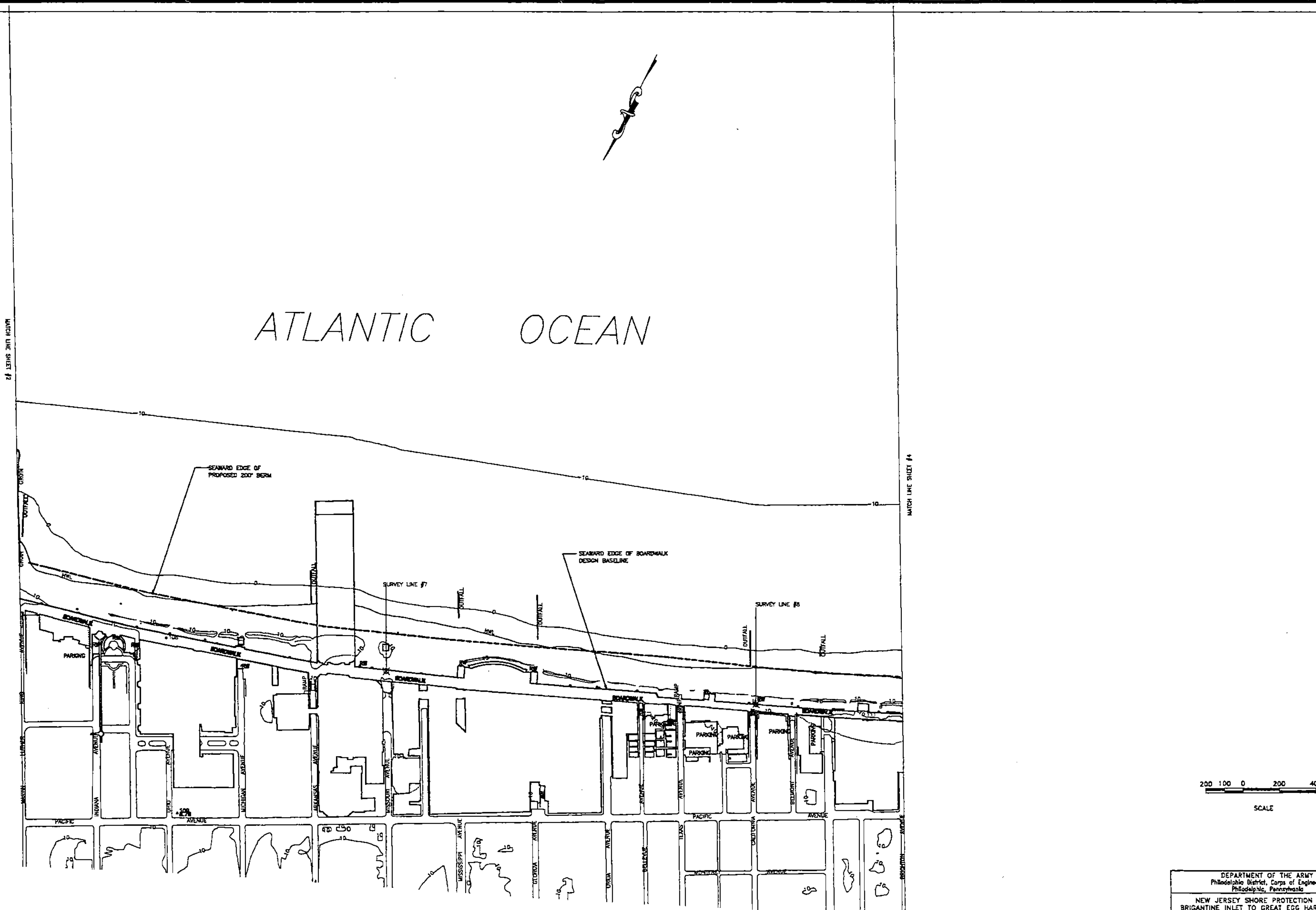
NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA
SELECTED PLAN

SHEET 2 OF 9



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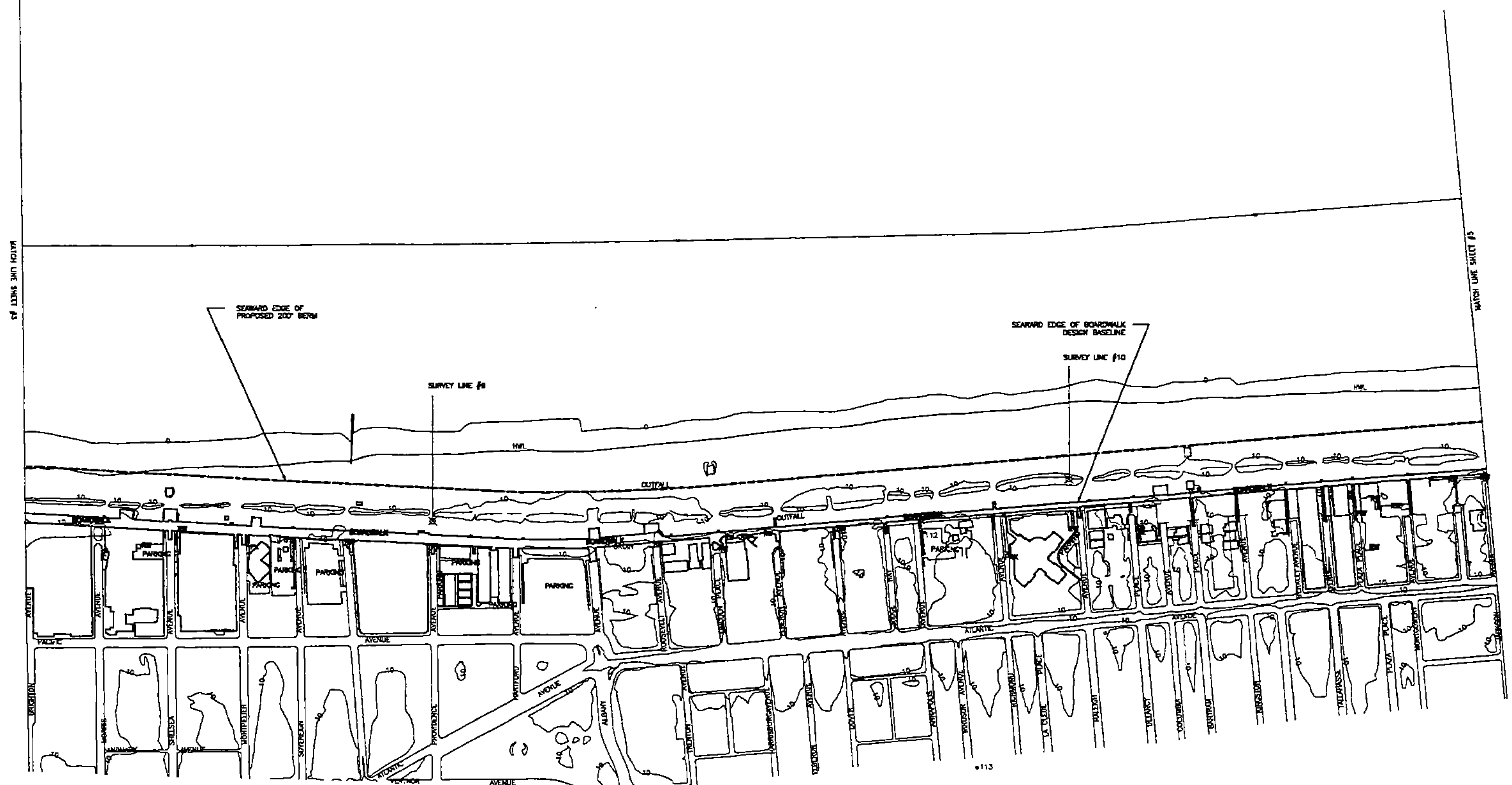
NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA
SELECTED PLAN

SHEET 3 OF 9



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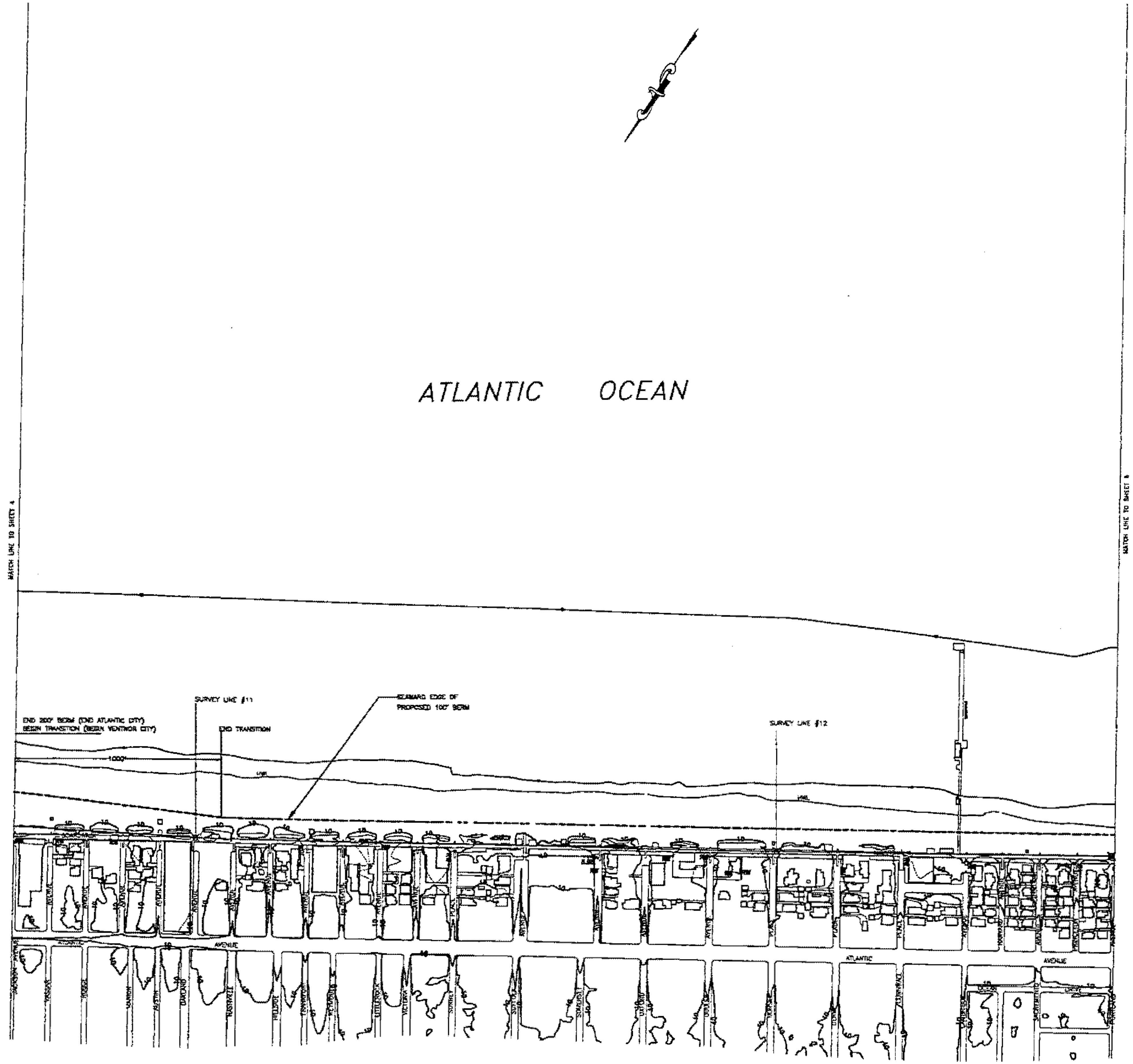
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA
SELECTED PLAN

4 of 9



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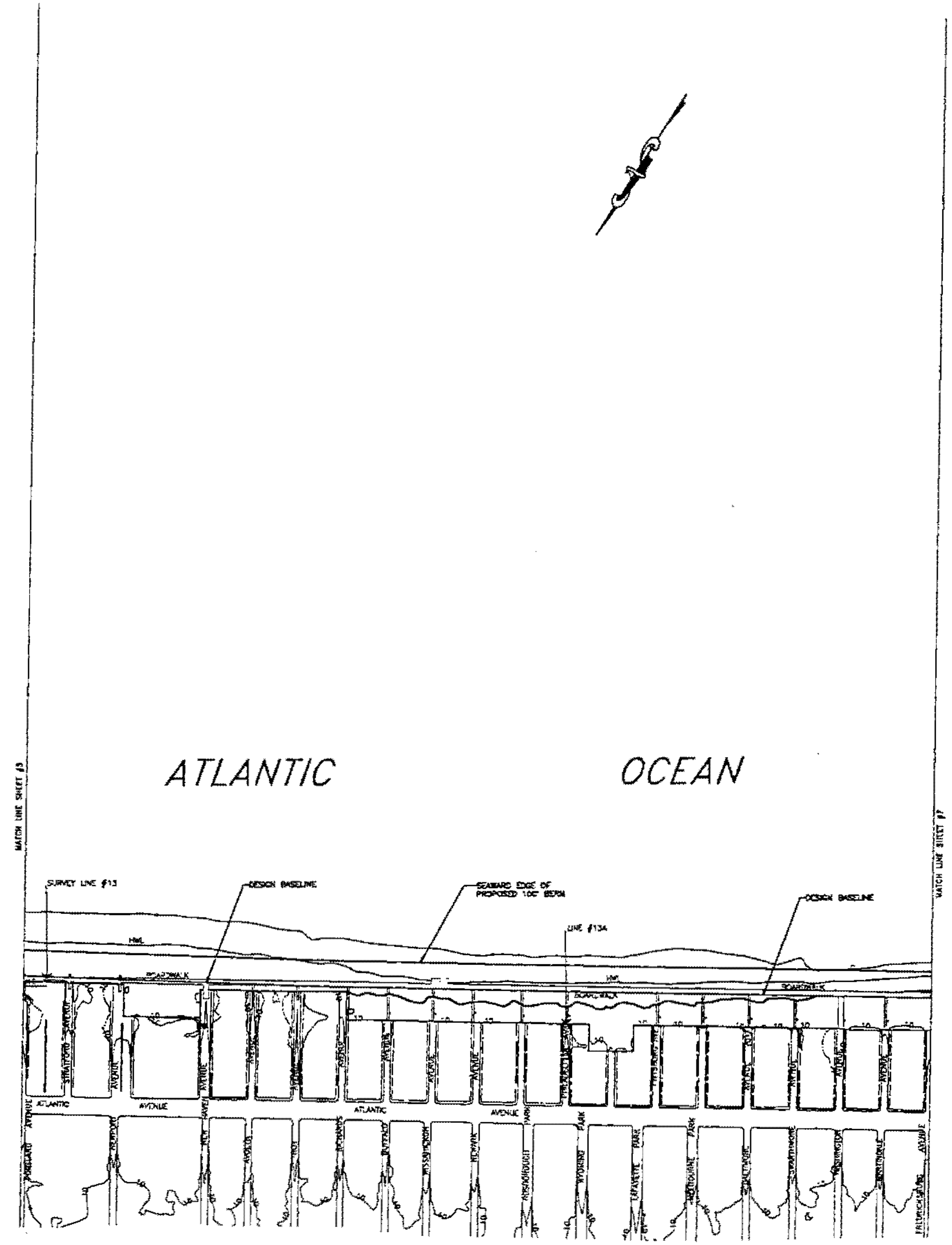
CONTOUR INTERVAL: 2'
DATE OF PHOTOGRAPHY: 9-24-93

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA

SHEET 5 OF 9



THE UNDERWATER CONTOURS SHOWN ON THIS MAP ARE APPROXIMATE.

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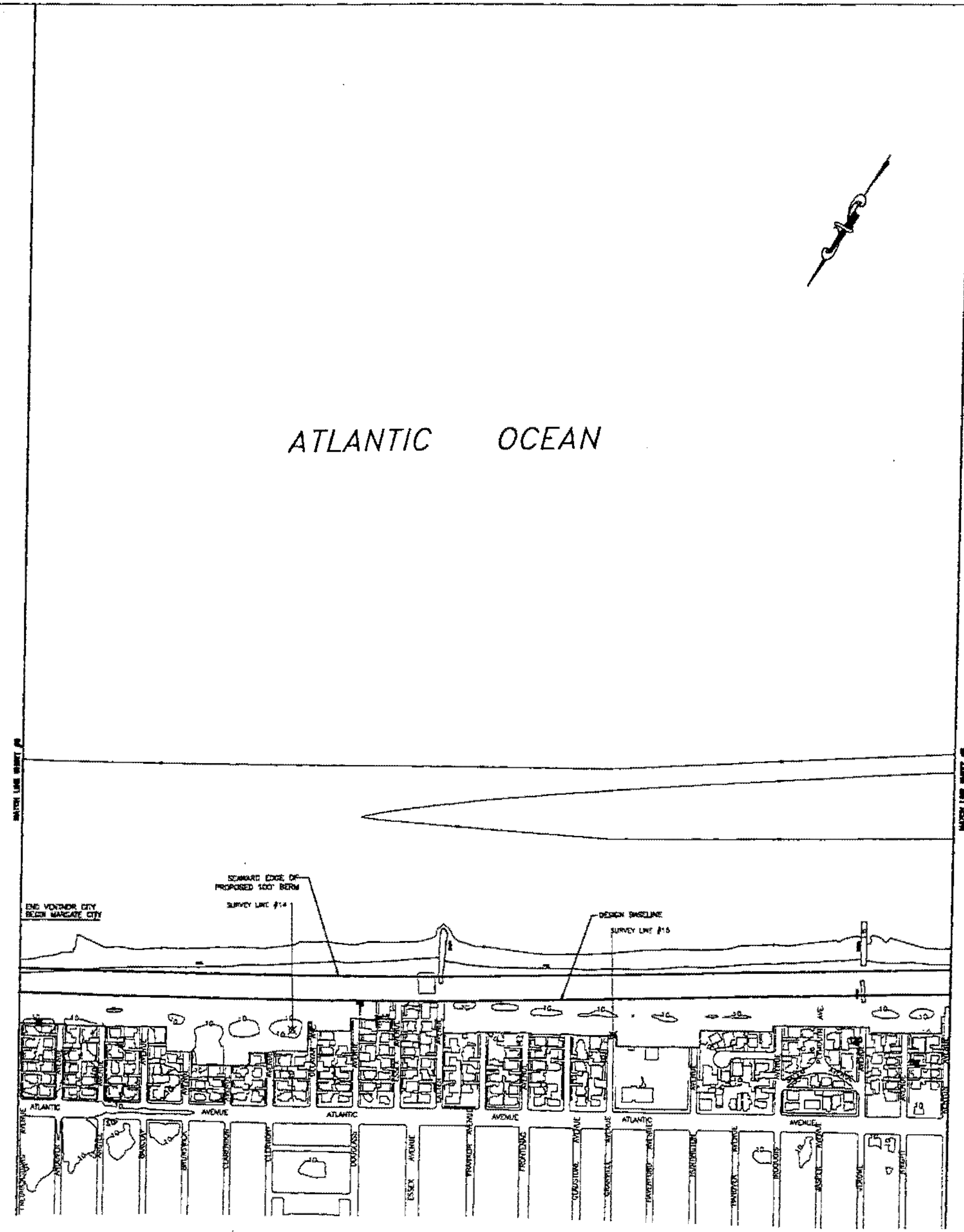
CONTOUR INTERVAL: 2'
DATE OF PHOTOGRAPHY: 9-24-93

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY
ABSECON ISLAND STUDY AREA
SELECTED PLAN

SCALE: AS SHOWN | SHEET 6 OF 8



THE UNDERWATER CONTOURS SHOWN ON THIS MAP ARE APPROXIMATE.

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DATE OF PHOTOGRAPHY: 9-24-93

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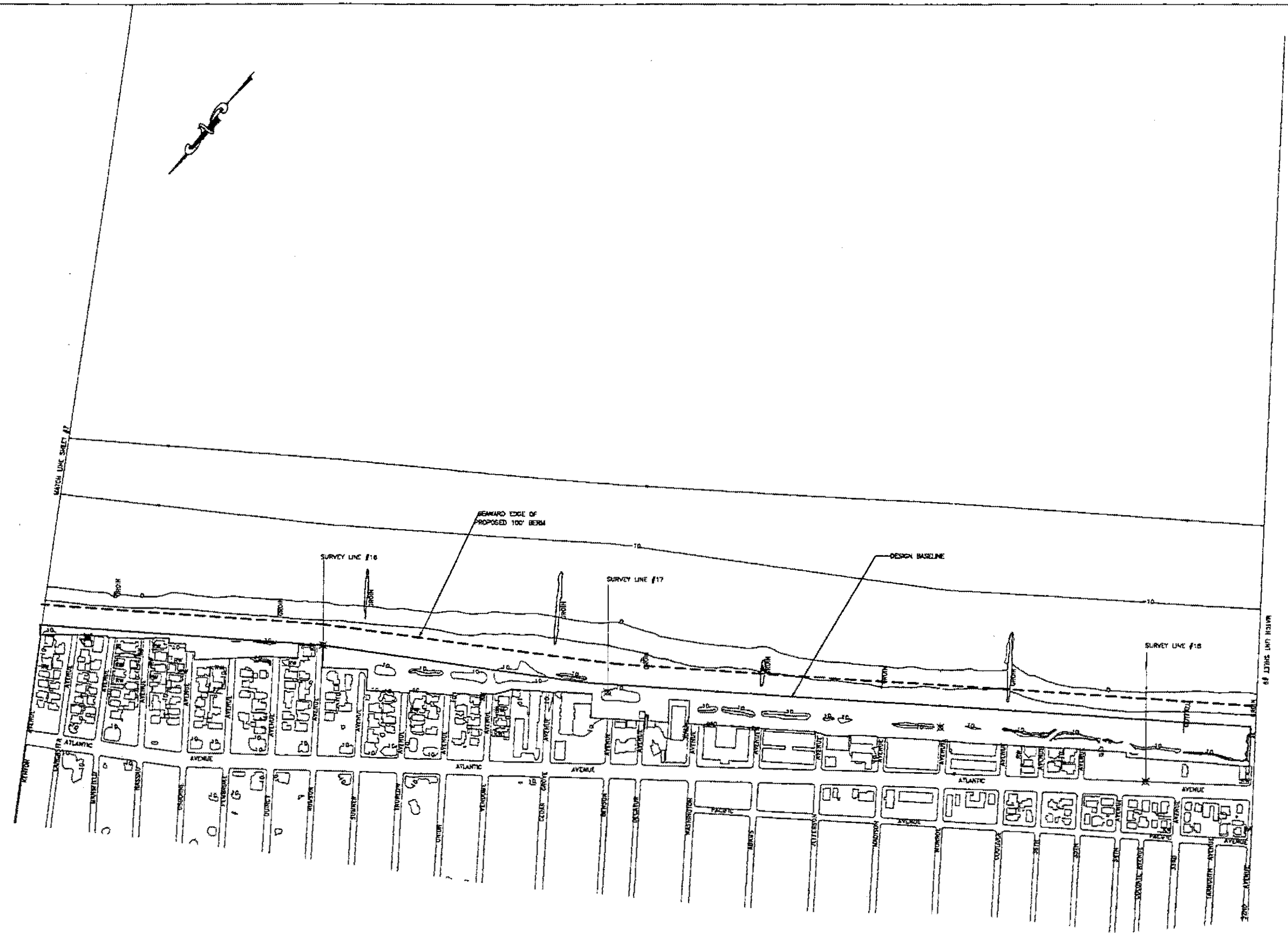
Philadelphia District, Corps of Engineers
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY
ABSECON ISLAND STUDY AREA
SELECTED PLAN

SHEET 7 OF 9



THE UNDERWATER CONTOURS SHOWN ON THIS MAP ARE APPROXIMATE.

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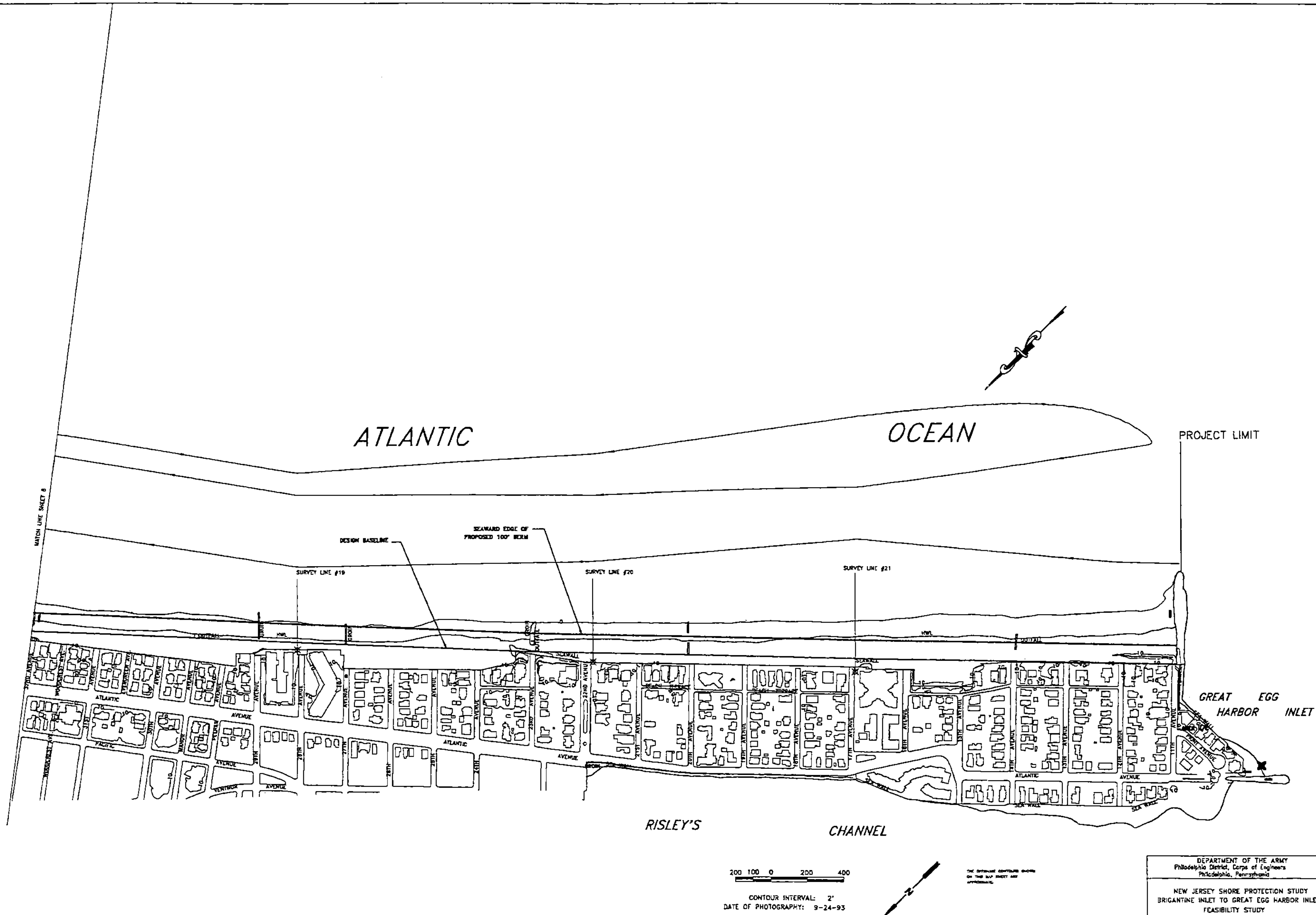
DATE OF PHOTOGRAPHY: 8-24-53

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA

SCALE AS SHOWN | SHEET 8 of 9



DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Philadelphia, Pennsylvania

NEW JERSEY SHORE PROTECTION STUDY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY

ABSECON ISLAND STUDY AREA

SCALE AS SHOWN | SHEET 9 OF 9

495. Beachfill Taper. At the northern end of the study area, no taper of the beachfill was required because the proposed beachfill will begin at the Oriental Avenue Jetty. At the southern limit of the study, no taper was required as the proposed beachfill ends at the terminal groin in the community of Longport.

496. Transition Taper. The selected plan incorporates a transition, 1000 feet in length, from the southern end of the 200 ft. berm width in Atlantic City to the beginning of the 100 ft. berm width in Ventnor.

497. Outfall Extensions. Outfalls that do not extend past the construction template will require extensions so that they remain functional. Outfall extension quantities and costs are given in detail in Appendix E. The total cost of all outfall extensions is $787,154. The annual operation and maintenance of the project includes repairs to the storm drain outfall pipes and timber crib structures that may be damaged by storms or suffer deterioration over time. The annual cost for these repairs is estimated to be $17,700 and is based on operation and maintenance experience for projects within the Philadelphia District having similar exposure to the ocean environment.

498. Major Rehabilitation. Major rehabilitation quantities were developed in accordance with ER1110-2-1407 to identify additional erosional losses from the project due to higher intensity (low frequency) storm events. The nourishment rates developed for the project alternatives include losses due to storms that have occurred within the analysis period, storms of approximately 50 year return period and more frequent are encompassed in those rates. Major rehabilitation losses are computed as the losses that would occur from the 50% risk event over the project life. The annual percent frequency event with a 50% risk during the 50 year economic project life is 1.37%. The period of record of stages recorded at the study area is approximately 73 years, and the storm of record was the March 1962 northeaster. This storm was not only the stage of record but also by far induced the greatest loss of beach material during the period. The 1962 northeaster was considered to be the 50% risk event for the purposes of the major rehabilitation analysis. SBEACH was employed to compute volumetric erosion from the selected beach alternative design profile utilizing the hydraulic input parameters from the 1962 northeaster. Water levels and waves were hindcasted at the study area for the storm, and all model parameters were identical to the without and with-project analyses. Volumetric storm induced erosion was computed within each cell for the design beach profile and then an average loss quantity was computed for Atlantic City, Ventnor, Margate and Longport. Based on methodologies and experience developed at the Philadelphia, Wilmington and New York Districts, Corps of Engineers, it is has been estimated that between 60 and 75 % of the material displaced during large storms will return to the foreshore within weeks and only the remaining 25 to 40 % will require mechanical replacement. Therefore, as an estimate of the necessary major rehabilitation quantity, a volume equal to 50% of the estimated eroded volume will require mechanical placement onto the beach to regain the design cross-section and insure the predicted level of storm damage reduction.

499. It is estimated that volumes of 335,850 and 297,830 cubic yards within Atlantic City and Ventnor Margate and Longport, respectively, would be required to perform major rehabilitation in response to the 50% risk event over the project life.

500. Absecon Inlet Frontage. The selected plan for the Absecon Inlet frontage consists of the construction of an anchored timber sheet-pile bulkhead in two separate sections; one from Madison Ave. to Melrose Ave., for a length of 550 feet, and one section from Atlantic Ave. to Oriental Ave., for a length of 1,050 feet. The timber sheet-pile bulkhead would be aligned with the existing bulkhead constructed along Maine Ave. at both locations. From Atlantic to Oriental Aves., the bulkhead would be located at the seaward edge of the existing boardwalk. Both sections of bulkhead would be constructed to a top elevation of +14 NGVD, with king piles and steel tie rods. A revetment of rough quarrystone with a ten foot crest width and seaward slope of 2H:1V will be constructed to an elevation of +5 NGVD on the inlet side of the bulkhead. This bulkhead would prevent damages from inundation and wave attack. A cross section of this bulkhead is shown in Figure 34. Analysis of revetment stone size is also presented in the Engineering Appendix.

501. Real Estate. Real estate requirements include fill easements, temporary and permanent access easements, and borrow area easements (see the Real Estate Plan, Appendix E). The borrow area easements will be provided at no cost by the State of New Jersey. Real estate acquisition costs are zero, however, administration costs associated with obtaining easements are estimated at $107,728. Storm drain outfall extensions are considered items of relocation and are the responsibility of the local sponsor.

INITIAL PROJECT COST ESTIMATE

502. The estimated first cost for the selected plan described above is $52,146,000 October 1995 price level) which includes interest during construction, real estate acquisition costs (including administrative costs), engineering and design (E&D), construction management (CM) and associated contingencies. E&D costs include preparation of plans and specifications, environmental, cultural and coastal pre-construction monitoring and the development and execution of the Project Cooperation Agreement (PCA). A summary of the first cost is shown in Table 46.

TABLE 46 TOTAL FIRST COST SUMMARY OCTOBER 1995 PRICE LEVELS						
Description of Item	Qty	Unit	Unit Price	Est. Amount	Contingency	Total Amount
Lands and Damages						
Post Authorization Planning	0	0	0	0	0	0
Relocations (Outfall extensions)	0	Job	LS	684,482	102,672	787,154
Required Easements Incl Surveys, Appraisal and Admin	0	Job	LS	93,675	14,053	107,728
Total Lands and Damages	0	0	0	778,157	116,725	894,882
Beach Replenishment and Bulkhead Construction						
Mobilization, Demobilization and Preparatory Work		Job	LS	378,515	45,422	$423,937
Beachfill	6,174,013	CY	5.64	34,821,433	5,204,693	$40,044,648
Dune Grass	440,440	SY	2.41	1,061,460	159,219	$1,220,679
Sand Fence	63,675	LF	3.89	247,696	37,154	$284,850
Bulkhead w/ revetment	1,600	LF	LS	4,461,006	669,152	$5,130,158
Planning, Engineering and Design (PED)		Job	LS	1,105,000	165,750	$1,270,750
Construction Management (S&A)		Job	LS	2,500,959	375,144	$2,876,103
Total Beach Replenishment				$44,576,069	$6,675,056	$51,251,125
Project Total						
Total Project First Cost				$45,354,226	$6,791,781	$52,146,007

503. Interest During Construction. Table 47 displays the calculations for interest during construction. The duration of construction for the project is estimated at nineteen months. It is assumed the construction costs would be evenly distributed over that period.

504. Total Sand Quantity Required. The beachfill project requires a conservative estimate of approximately 32 million cubic yards over its anticipated 50 year project life. Initial construction of the project would require approximately 6.2 million cubic yards while the periodic nourishment is estimated at 1.7 million cy every three years. Approximately 300,000 cy of material per year is estimated to infill the Absecon Inlet borrow site (Site A) between nourishment intervals (900,000 total for the 3 yr cycle). This is a difficult quantity to predict and is viewed as a conservative estimate, particularly after the project is constructed. Our sediment budget analyses (Appendix A) indicate that there is considerably more sand currently being transported in the littoral system along Absecon Inlet (on the order 550,000 cy).

505. Following the construction of the project, additional sand will become available to the ongoing littoral processes. Thus, there should be a significant increase in the gross transport of sand, most notably from the northern portion of Atlantic City, both north into the inlet as well as further south along Absecon Island. In addition, once the Absecon Inlet borrow site has been dredged, it will create a localized sediment sink which will be more effective at trapping sand entrained in the littoral system. Therefore, the actual infilling of Site A may be greater than predicted. This would cause Site A to have additional longevity over what is currently estimated.

506. Based on existing bathymetry (1994), Site A contains approximately 10.3 million cy of beach quality sand. An additional 1 million cy of material is estimated to naturally deposit into Site A area prior to construction, for a future total of approximately 11.3 million cy. Assuming an initial beachfill requirement of 6.2 million cy, that would leave a balance of just over 5 million cy for future nourishment efforts (in addition to the infilling volume of 900,000 cy per 3 yr cycle). Therefore, the Absecon Inlet site can reasonably be expected to be the sole source of beachfill material for the initial construction and first six to seven nourishment efforts (approximately years 2019-2022). Post project monitoring will confirm the actual beach losses and borrow site infilling. Changes in nourishment requirements, grain size distributions, infilling rates, etc., could either increase or decrease the projected time horizon for sole utilization of Site A for sand mining. Supplemental sand requirements during the life of the project would then be available from the other two borrow sites identified, or other alternative future sites, on an as needed basis.

507. Periodic Nourishment. Periodic nourishment is expected to occur at 3 year intervals subsequent to the completion of initial construction. Based on a volume of 1,666,000 cubic yards for each nourishment cycle, the total cost per operation, or cycle, is estimated to be $12,188,000 (October 1995 price levels). The total estimated annualized cost of periodic nourishment is $8,133,859 over the 50 year life of the project.

508. Annualized Construction Costs. Annualized costs including first costs, real estate costs, interest during construction, and major rehabilitation costs are shown in table 48.

509. Project Monitoring Plan. The project monitoring plan will document beach fill performance

and determine conditions within the borrow areas. Periodic assessments will assist in determining renourishment quantities. The program was developed in accordance with EM-1110-2-1004, ER-1110-2-1407, CETN-II-26 and the draft CETN dated 3/13/95 entitled "Recommended Base-level Physical Monitoring of Beach Fills." The following items are to be included in the project monitoring plan: Pre- and post-construction monitoring will consist of beach profile surveys, sediment sampling of the beach and borrow areas, aerial photography, and tidal data collection. The field data collection will be followed up by lab and data analyses. The proposed monitoring program will begin at the initiation of pre-construction efforts and continue throughout the project life. The monitoring program is further described in Appendix A, Section 2. Costs of the monitoring plan can be seen in table 49.

Table 47

ABSECON ISLAND INTEREST DURING CONSTRUCTION			
Discount Rate:		7.625%	
Use Date:		Apr-1999	
Start Date:		Nov-2000	
	Monthly	Interest	Total
MONTH	Costs	Factor	Cost
1	$3,942,725	1.123386	$4,429,204
2	$2,671,975	1.116528	$2,983,336
3	$2,671,975	1.109712	$2,965,123
4	$2,671,975	1.102937	$2,947,021
5	$2,671,975	1.096204	$2,929,030
6	$2,671,975	1.089512	$2,911,149
7	$2,671,975	1.082861	$2,893,377
8	$2,671,975	1.076250	$2,875,713
9	$2,671,975	1.069680	$2,858,157
10	$2,671,975	1.063149	$2,840,709
11	$2,671,975	1.056659	$2,823,367
12	$2,671,975	1.050208	$2,806,130
13	$2,671,975	1.043797	$2,788,999
14	$2,671,975	1.037425	$2,771,973
15	$2,671,975	1.031091	$2,755,050
16	$2,671,975	1.024797	$2,738,231
17	$2,671,975	1.018540	$2,721,515
18	$2,671,975	1.012322	$2,704,900
19	$2,671,975	1.006142	$2,688,387
Total First Cost:	$52,146,000		
	Total Investment Cost:		$55,546,000
	Minus First Cost:		$52,146,000
	Interest During Construction:		$3,400,000

Table 48

ABSECON ISLAND BEACHFILL & NOURISHMENT PRESENT WORTH ANALYSIS				
Base Year:	2001		Discount Rate:	7.625%
Type	Year	Cost	PW Factor	PW Cost
Initial Cost	0	52,038,300	1.000000	52,038,300
Real Estate (Admin. Costs)	0	108,000	1.000000	108,000
IDC	0	3,400,000	1.000000	3,400,000
Periodic Nourishment	3	12,187,595	0.802159	9,776,390
Periodic Nourishment	6	12,187,595	0.643459	7,842,220
Periodic Nourishment	9	12,187,595	0.516157	6,290,708
Periodic Nourishment	12	12,187,595	0.414040	5,046,149
Periodic Nourishment	15	12,187,595	0.332126	4,047,814
Periodic Nourishment	18	12,187,595	0.266418	3,246,991
Periodic Nourishment	21	12,187,595	0.213709	2,604,603
Periodic Nourishment	24	17,372,450	0.171429	2,978,140
Periodic Nourishment	27	12,187,595	0.137513	1,675,956
Periodic Nourishment	30	12,187,595	0.110308	1,344,383
Periodic Nourishment	33	12,187,595	0.088484	1,078,409
Periodic Nourishment	36	12,187,595	0.070978	865,056
Periodic Nourishment	39	12,187,595	0.056936	693,912
Periodic Nourishment	42	12,187,595	0.045672	556,628
Periodic Nourishment	45	12,187,595	0.036636	446,504
Periodic Nourishment	48	12,187,595	0.029388	358,167
			TOTAL	104,398,331
Capital Recovery Factor (50 Years @ 7.625%):				0.078235
AVERAGE ANNUAL COSTS:				**$8,167,600**

Table 49

MONITORING COSTS PRESENT WORTH COST ANALYSIS				
Base Year		2001	0	
Discount Rate		7.625%		
TYPE	YEAR	COST	PW FACTOR	PW COST
Monitoring	0	0	1.000000000	0
Monitoring	1	284000	0.929152149	263879
Monitoring	2	251000	0.863323715	216694
Monitoring	3	284000	0.802159085	227813
Monitoring	4	251000	0.745327838	187077
Monitoring	5	284000	0.692522962	196677
Monitoring	6	251000	0.643459198	161508
Monitoring	7	284000	0.597871496	169796
Monitoring	8	251000	0.555513585	139434
Monitoring	9	284000	0.516156641	146588
Monitoring	10	251000	0.479588052	120377
Monitoring	11	284000	0.445610269	126553
Monitoring	12	251000	0.414039739	103924
Monitoring	13	284000	0.384705913	109256
Monitoring	14	251000	0.357450326	89720
Monitoring	15	284000	0.332125738	94324
Monitoring	16	251000	0.308595344	77457
Monitoring	17	284000	0.286732027	81432
Monitoring	18	251000	0.266417679	66871
Monitoring	19	284000	0.247542558	70302
Monitoring	20	251000	0.230004700	57731
Monitoring	21	284000	0.213709361	60693
Monitoring	22	251000	0.198568512	49841
Monitoring	23	284000	0.184500360	52398
Monitoring	24	251000	0.171428906	43029
Monitoring	25	284000	0.159283536	45237
Monitoring	26	251000	0.147998640	37148
Monitoring	27	284000	0.137513254	39054
Monitoring	28	251000	0.127770736	32070
Monitoring	29	284000	0.118718454	33716
Monitoring	30	251000	0.110307506	27687
Monitoring	31	284000	0.102492456	29108
Monitoring	32	251000	0.095231086	23903
Monitoring	33	284000	0.088484168	25130
Monitoring	34	251000	0.082215255	20636
Monitoring	35	284000	0.076390481	21695
Monitoring	36	251000	0.070978379	17816
Monitoring	37	284000	0.065949714	18730
Monitoring	38	251000	0.061277318	15381
Monitoring	39	284000	0.056935952	16170
Monitoring	40	251000	0.052902162	13278
Monitoring	41	284000	0.049154158	13960
Monitoring	42	251000	0.045671691	11464
Monitoring	43	284000	0.042435950	12052
Monitoring	44	251000	0.039429454	9897
Monitoring	45	284000	0.036635962	10405
Monitoring	46	251000	0.034040383	8544
Monitoring	47	284000	0.031628695	8983
Monitoring	48	251000	0.029387870	7376
Monitoring	49	284000	0.027305802	7755
Monitoring	50	0	0.025371245	0
			TOTAL	3,420,567
Capital Recovery Factor (50 Years @ 7.625%)				0.07823491724
	AVERAGE ANNUAL COSTS			$267,608

TOTAL ANNUALIZED COSTS

510. The estimated total annualized cost of the selected plan is $8,504,281, which is based on an economic project life of 50 years and an interest rate of 7.625% (October 1995 price levels). This cost includes the annualized first cost, interest during construction, annualized periodic nourishment costs, annualized major rehabilitation costs and post construction monitoring costs.

511. CONSTRUCTION AND FUNDING SCHEDULE. An estimated schedule of expenditures by year is shown in the Project Management Plan (PMP). The PMP describes activities leading to, through and after construction of the selected plan.

INCIDENTAL BENEFITS

512. RECREATION BENEFITS. Incidental recreation benefits are included in the final accounting of total benefits of the selected plan.

513. Without Project Conditions. New Jersey Beaches are consistently the number one travel destination in New Jersey. Tourist dollars contribute directly and indirectly to the regional economy. In 1992, the New Jersey Travel Research Program reported that travel and tourism generated 346,000 jobs in the state with a total payroll of $7.6 billion. In addition, the number of visitors to Atlantic City has recently experienced a slight increase. In 1994 the total number of visitors was an estimated 31.3 million according to the South Jersey Transportation Authority. This represented a 3.6% increase over the previous year's visitor count.

514. A contingent valuation method survey was completed by the Rutgers State University for the New Jersey Department of Environmental Protection and the U.S. Army Corps of Engineers to determine willingness to pay for the existing beach and an enhanced beach. This is done on a regional basis, encompassing the major beach communities of Atlantic City, Ventnor, Margate, and Longport. It consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach during the summer of 1994.

515. Beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. Respondents voiced similar desires. The primary factors of consideration were the quality of the beach scenery, how well maintained the beach was, the width of the beach, the number of lifeguards, and how family oriented was the beach.

516. The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time was it very crowded (only 2 feet between towels). Further it was determined that crowding was not considered a very important issue to the majority of beachgoers by asking respondents how important being alone is and how important is it to be with a large number of people. As might be expected, areas with more crowding tended to be frequented by people who like large numbers.

People who like to be alone frequented areas that tended to have little crowding.

517. To estimate the value of the beach as it exists currently, an iterative bidding process was applied. Beachgoers were first asked if a day at the beach would be worth $4.00 to each member of their household. Based on their answers, they were then asked progressively higher or lower amounts until the amount they value the beach was determined. Using this method it was found that the average value of a day at the beach is $4.22.

518. With Project Conditions. The beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority were unwilling to pay any extra, 16% were willing to pay, on average, $2.92 more per visit. This would be equivalent to an average of $0.47 for all beachgoers.

519. The number of visitor days was estimated by multiplying the number of beach tag sales by the number of days the tags are usable. This was then multiplied by 1.062 to capture the percentage of people who use the beach without buying a beach tag. Lastly, 30% is subtracted from the number to account for inclement weather. For Atlantic City, which does not sell beach tags, the number was taken from city estimates. The total number of visitor days for beaches within the project area are estimated at 14,815,000.

520. Benefits were not found to accrue from increased capacity because crowding was found not to be a significant factor. However benefits do arise from an increase in the value of the recreational experience.

521. Benefits resulting from this increase in recreational experience were calculated by multiplying $0.47 by the number of visitors days within the project area or 14,815,000. This gives total recreational benefits of $6,963,000. A breakdown of benefits for each community are as follows in table 50:

Table 50
Recreation Benefits

Community	Visitor Days	Day Value	Total Value
Atlantic City	9,800,000	$0.47	$4,606,000
Margate	2,093,000	$0.47	$983,710
Ventnor	2,267,000	$0.47	$1,065,490
Longport	655,000	$0.47	$307,850
Total	14,815,000	$0.47	$6,963,050

522. REDUCED MAINTENANCE BENEFITS. In addition to storm damage reduction benefits, reduced maintenance benefits accrue under the with-project scenario. It is anticipated that the proposed berm and dune restoration plan for Atlantic City will result in a yearly reduction in local maintenance and repair costs of $2,000. The geotube installation sustained minor damages by the passing offshore of Hurricane Erin in 1995. At the time, there was virtually no beach fronting the geotubes. Waves removed the sand veneer and undercut portions of geotubes. With a 200 ft berm in place, it is assumed that under high frequency storm conditions, damage to the geotubes will be prevented, thereby eliminating the need for maintenance.

523. It is also anticipated that maintenance of other shore protection structures will be reduced, however reliable figures are unavailable. The benefits claimed in this category are therefore considered conservative.

524. BENEFITS DURING CONSTRUCTION. The NED project will be constructed over nineteen months. Significant portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. The total annualized benefits during construction are $479,000. Table 51 displays the monthly benefits during construction and the average annual benefits this adds to the overall benefits.

Table 51

ABSECON ISLAND BENEFITS DURING CONSTRUCTION				
	Discount Rate:		0.07625	
	Use Date:		Apr-1999	
	Start Date:		Nov-2000	
Month	Work	Monthly Benefit	Interest Factor	Total Benefit
1	Mob.	0	1.123386	0
7	Atlantic City	400,106	1.082861	433,259
8	Atlantic City	400,106	1.076250	430,614
9	Atlantic City	400,106	1.069680	427,985
10	Atlantic City	400,106	1.063149	425,372
11	Atlantic City	400,106	1.056659	422,776
12	Atlantic City	400,106	1.050208	420,195
13	Atlantic City	400,106	1.043797	417,629
14	Atlantic City	400,106	1.037425	415,080
15	Atlantic City	400,106	1.031091	412,546
16	Atlantic City	400,106	1.024797	410,027
17	Atlantic City	400,106	1.018540	407,524
18	Ventnor-Margate-Longport	742,628	1.012322	751,779
19	Demob	742,628	1.006142	747,189
	TOTAL	$5,886,422		$6,121,976
Capital Recovery Factor (50 Years @ 7.625%):				0.078235
Benefits During Construction:				$479,000

ECONOMICS OF THE NED PLAN

525. BENEFIT-COST RATIO. With the inclusion of the recreation benefits, the combined project (both reaches) for the study area provides total average annual benefits of $16,356,000 at a total average annual project cost of $8,486,000. Total average annual benefits are displayed by category in Table 52, along with annualized costs, and the resulting benefit-cost ratio. The result is a benefit-cost ratio of 1.9 with $7,870,000 in net benefits.

Table 52
BENEFIT-COST COMPARISON FOR THE NED PLAN

Discount Rate:	7.625%
Project Life:	50 Years
Price Level:	Oct. 1995
Base Year:	2001
BENEFITS:	
Storm Damage Reduction	$8,912,000
Reduced Maintenance	2,000
Recreation	6,963,000
Benefits During Construction	479,000
Total Average Annual Benefits	$16,356,000
COSTS:	
Initial Construction Costs	$52,146,000
Interest During Construction	3,400,000
Periodic Nourishment (per cycle)	12,188,000
Average Annual Construction Costs	$8,168,000
Average Annual Monitoring Costs	$268,000
Average Annual O&M Costs	$51,000
Total Average Annual Costs	$8,486,000
Benefit-Cost Ratio	**1.9**
Net Benefits	**$7,870,000**
Residual Damages	**$3,535,000**

PROJECT IMPACTS

526. IMPACTS TO ENVIRONMENTAL RESOURCES. The primary adverse impact of the beach nourishment alternative is the temporary disturbance and destruction of existing benthic

resources from dredging operations at the borrow area and fill placement along the shorefront. Dredging in the borrow area will result in a temporary destruction of the benthic community, however, rapid recolonization is expected to occur within one year from the dredging. Minor shifts in benthic community composition may occur following recolonization. Beachfill operations along Absecon Island will result in temporary degradation of the existing beach habitat during initial construction and the periodic nourishments. Existing benthic organisms on the beach would become buried as a result of beachfilling operations. Due to the presence of species adapted to high energy and dynamic conditions, recolonization of the beach area is expected to be rapid. The portion of benthic habitat covered by any seaward extension of the beach would represent a long-term loss, however, this would be offset by the creation of similar habitat. The partial burial of groins in the project area would represent a long-term loss of rocky inter-tidal habitat occupied by aquatic invertebrates that attract birds and fish. Fish and avian utilization of the immediate shoreline area for feeding would be temporarily disrupted, however, they are expected to return immediately after the disturbance. Dredging and the hydraulic placement of beachfill material will result in temporary higher turbidity levels at the borrow site and waters along the shoreline during construction.

527. In order to minimize the impacts to surf clams within the project area, dredging activities will primarily take place within the Absecon Inlet borrow area for the initial construction, as well as the subsequent nourishment cycles. If, due to available sand quantities, it becomes necessary to utilize one of the other borrow areas for subsequent nourishment cycles, updated surveys will be done to determine current populations. Measures will be taken in Absecon Inlet, as well as the other borrow areas if necessary, to minimize impacts to the clams. Some of these measures may include the commercial harvest of clams prior to dredging and only disturbing a portion of the site. All measures will be fully coordinated with the appropriate Federal, state and local agencies.

528. The piping plover, which is a frequent inhabitant of New Jersey's sandy beaches. Past nesting sites of this species in New Jersey have included the southern end of Brigantine, Ocean City, and several locations in Cape May. No known nesting sites have been identified within the study area on Absecon Island. Based on the high development and human disturbance, it is unlikely for piping plovers to nest within the project area. However, if a piping plover nest is discovered within the project area prior to the commencement of initial beach nourishment and periodic nourishment activities, the Corps will contact the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife and the U.S. Fish and Wildlife Service to determine appropriate measures to protect the piping plovers from being disturbed. These measures may include establishing a buffer zone around the nest, and limiting construction to be conducted outside of the nesting period (1 April - 15 August).

529. The construction of the timber sheet-pile bulkheads and placement of a quarrystone revetment will also result in temporary higher turbidity levels and the disturbance of the benthic community within the inlet. This aspect of the proposed plan will result in the loss of sandy bottom habitat and the destruction of the benthic community within the area to be covered by the bulkheads and associated revetment. Once construction is completed, it is expected that the newly created rocky inter-tidal habitat will be colonized with a variety of marine organisms.

530. Depending on the dredging method to be used, it may be necessary to employ sea turtle monitors on the dredges to comply with Section 7 of the Endangered Species Act.

531. Periodic dredging in the borrow area for beach renourishment may affect a potentially recovering surf clam population. The resource agencies will be contacted prior to renourishment cycles in order to determine if monitoring is appropriate.

532. Mitigation measures were incorporated into the determination of the optimal nourishment interval. The mitigation measures were initiated by the selection of the beach nourishment alternative. This alternative offers a more naturalistic and softer approach for storm damage reduction. Selection of this alternative is based on its relatively low ecological impacts and its cost effectiveness. Another institutional measure is the utilization of offshore sand borrow areas. These are characterized by high energy and shifting sands resulting in a benthic community of lower abundance and diversity as compared to more stable benthic environments. Therefore, biological impacts are expected to be lower. Another measure is the selected use of suitable sand grain sizes for beach nourishment. The selection of borrow areas is based on compatibility studies for sand grain sizes. The selection of coarser beach nourishment quality material will minimize impacts on water quality at the dredging site and discharge (placement) site. A more detailed discussion of the mitigation effort is detailed in Section 5.16 of the FEIS.

533. Aesthetics. Beach nourishment is a more natural and soft structural solution to reducing storm damages on Absecon Island. With the exception of short-term impacts during construction, overall aesthetics of the beach would be improved as a result. A natural-looking beach and dune would be more aesthetically pleasing and attractive to residents and tourists. However, despite the visual benefits the beach nourishment alternative would provide, a restored dune may inhibit ocean views in some project impact areas.

534. The boardwalk elevations on Absecon Island range from 10.5 to 15 feet NGVD. At the lower elevations, views of the ocean may be impacted. However, of the 3.4 miles of boardwalk in Atlantic City, only seven percent is below 11 feet NGVD. Therefore, in these areas, the possibility exists for some aesthetic impacts in terms of the accessibility of wave and ocean views. Currently there are some areas within Absecon Island that have limited views of the ocean. This is due to the fact that dune repairs/restoration have been made in some areas which have increased the height of the dunes. This, combined with the narrow width of the beach, leaves the waves breaking close to the toe of the dunes and hampering the visual aesthetics. If the dunes for the proposed project were built on the current beach, aesthetic impacts would also exist due to the fact that currently the waves break very close to the toe of the dune in many areas of the project. Once the proposed beachfill is in place however, the area where the waves break will be much further from shore, therefore making the waves easier to see from the boardwalk, and minimizing negative aesthetic impacts.

535. IMPACTS TO CULTURAL RESOURCES. On the basis of the current project plan, the Corps is of the opinion that proposed dredging operations at borrow areas, fill placement along the shoreline and within near-shore underwater locations, and bulkhead and revetment

construction adjacent to the inlet will have no effect on significant cultural resources.

536. The remote sensing investigation of the borrow areas identified five magnetic targets exhibiting shipwreck characteristics. Proposed sand borrowing activities could adversely impact these target locations, which may represent significant cultural resources. Therefore, in order to eliminate construction impacts at these locations, the Philadelphia District proposes to completely avoid these remote sensing targets during sand borrowing operations by delineating at least a 200 foot buffer around each target (see figure 54).

Absecon Inlet Borrow Site with Exclusion Zone Locations

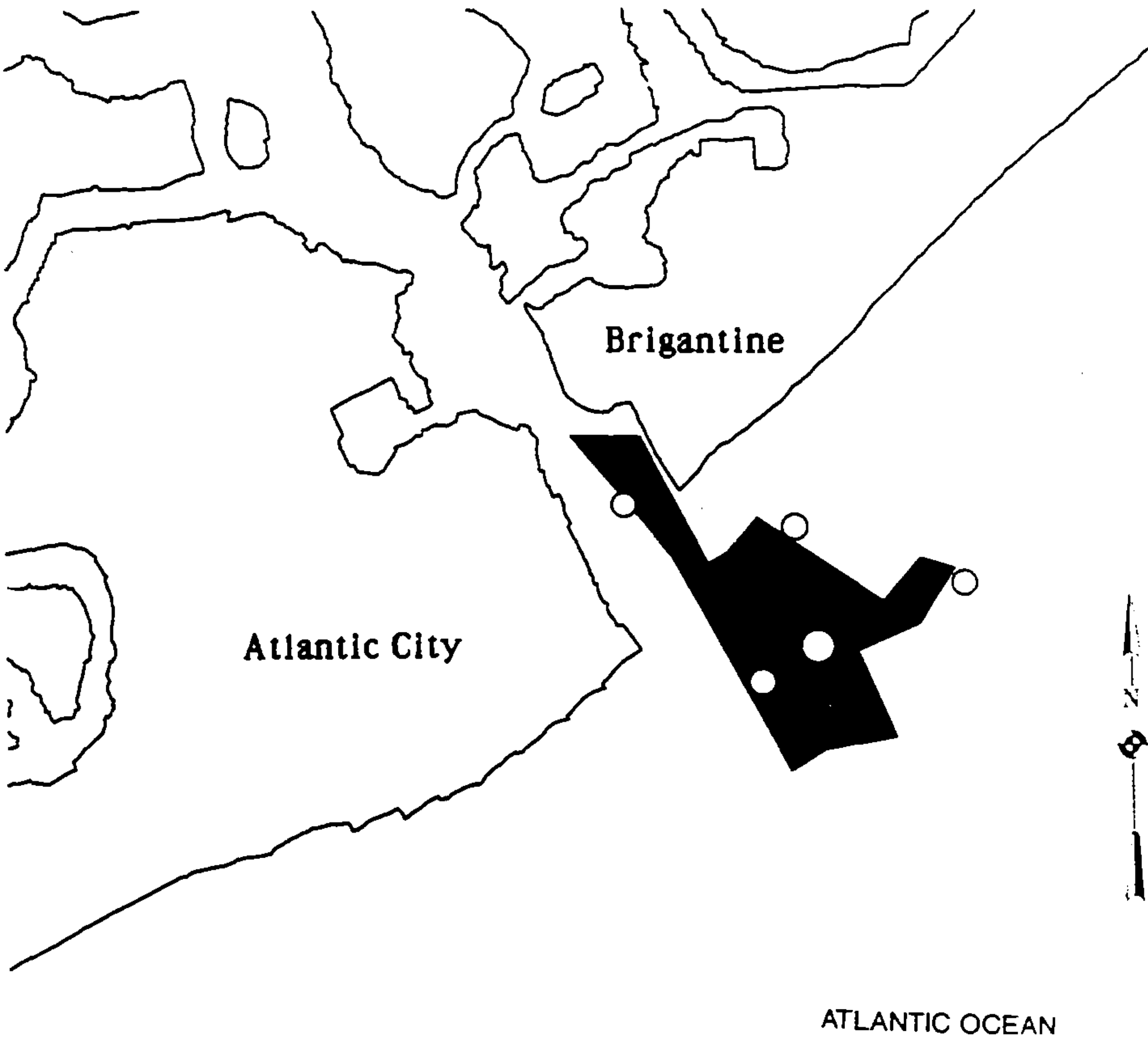


FIGURE 54

537. A low-tide pedestrian survey conducted along the shoreline did not identify any prehistoric or historic archaeological sites within the project boundaries. Two potentially significant historic entertainment piers, the Steeplechase Pier and the Garden Pier, are located in the project area and will not be impacted by fill placement. Near-shore underwater project areas were not investigated for cultural resources. Remote sensing survey within this high energy surf-zone is dangerous and extremely difficult. The likelihood for intact and undisturbed cultural resources in such an unstable and shifting coastal environment is very minimal.

538. Timber sheet-pile bulkhead and quarrystone revetment construction is limited to previously disturbed areas adjacent to Maine Avenue and within Absecon Inlet. Previous bulkhead construction and inlet dredging activities have minimized the likelihood for significant cultural resources in these locations. Therefore, cultural resources, pedestrian or remote sensing surveys were not conducted in these areas.

539. RISK AND UNCERTAINTY ASSOCIATED WITH COASTAL PROJECTS. The Corps of Engineers has a long history of planning coastal protection measures as well as other types of water resources development projects. By providing protection against coastal hazards, gains in economic efficiency can be achieved that result in an increase in the national output of goods and services. A comprehensive guide for calculating NED benefits primarily for storm damage reduction and shore protection projects is contained in IWR Report 91-R-6 National Economic Development Procedures Manual - Coastal Storm Erosion, U.S. Army Corps of Engineers, Institute for Water Resources, September 1991.

540. Coastal protection projects, like all investments, involve an outlay of capital at some point in time in order to gain predicted benefits in the future. In addition, certain types of projects, particularly beach fill and periodic nourishment projects, require a commitment to substantial future spending to sustain the projects and continue to gain the related benefits. In 1956, Congress defined periodic nourishment as construction for the protection of shores when it is the most suitable and economical remedial measure. One advantage to soft engineering options, such as beach fill, is that they do not represent an irrevocable commitment of funds. They can be discontinued at any future point in time, eventually allowing a return to the pre-project condition, without further expenditures.

541. In all evaluations, the aspect of future costs and benefits requires that the current and future dollar costs and benefits be compared in a common unit of measurement. This is typically accomplished by comparing their present values or the average annual equivalent of their present values. Therefore, the discount or interest rate used to determine the present values influences the relative economic feasibility of alternative project types. Since high discount rates reduce the influence of future benefits and costs on present values, high interest rates generally favor the selection of projects with low first costs but relatively high planned future expenditures over those with high first costs but low future cost requirements. This factor, among other important considerations, tends to favor the wide use of beach fills, dunes, and accompanying renourishment relative to an extensive use of hard structural shore protection measures.

542. One standard for identifying and measuring the economic benefits from investments in a water resources project such as shore protection, is each individual's willingness to pay for that project. For coastal projects, this value can be generated by a reduction in the cost to a current land-use activity or the increase in net income possible at a given site. A project generates these values by reducing the risk of storm damage to coastal development. Conceptually, the risk from storms can be viewed as incurring a cost to development, i.e., capital investment, at hazardous locations. Thus, the cost per unit of capital invested at risky locations is higher than at lesser risk locations.

543. Natural Sources of Risk and Uncertainty. Storms and severe erosive processes damage coastal property in several ways. In addition to direct wind-related damage, which is ignored for purposes of this discussion, a storm typically produces an elevated water surface or surge above the normal astronomical tide level. This storm-driven surge is often sufficient, even without the effects of waves, to be life-threatening and/or to cause substantial inundation damages to property.

544. In addition to the surge, coastal storms generate large waves. Properties subject to direct wave attack usually suffer extensive structural and content damages as well as foundation scouring which can totally destroy structures. Storms also produce at least temporary physical changes at the land-water boundary by eroding the natural beach and dune that serve to buffer and protect shorefront property from the effects of storms. Increased wave energy during storms erodes the beach and carries the sand offshore. At the same time, the storm surge pushes the zone of direct wave attack higher up the beach and can subject dunes and, in turn, upland structures to direct wave action.

545. Frameworks for Deterministic and Risk-Based Evaluations. The first step in a project feasibility evaluation is to assess the baseline conditions, i.e., the conditions that would likely exist if a project was never implemented to address the existing problems in a systematic fashion. In the deterministic approach, which is currently the basic approach used by the Corps of Engineers, a single forecast defines physical, developmental, cultural, environmental and other changes expected to occur under the baseline or "without-project" condition. These changes are considered to occur with certainty in the absence of any systematic adaptive measure of the type being considered as a project. This approach does allow, however, for individual property owners to respond to storm and erosion threats by constructing protective measures or by abandoning property. It also takes into account other systematic measures that are in place or expected to be instituted such as existing state, county or municipal protective measures, evolving building codes and changing land-use controls.

546. Benefits produced by a project depend on the project's type, scale, and storm parameters. Even if two alternative projects constructed side by side experience the same storm, benefits will differ, depending on the magnitude of residual losses if the storm exceeds the alternatives' design dimensions. As an example, a beach fill, even when inundated during a storm, still provides significant residual protection. Another significant factor is that in the coastal process, the wide range of storm parameters (wind direction, wind velocity, storm surge, storm duration, etc.)

results in multiple storm damage mechanisms.

547. In addition to NED benefits, a second major consideration in applying benefit- cost analysis in choosing a particular type and size project is the stream of future project costs. The appropriate costs used in the analysis should provide a measure of all the opportunity costs incurred to produce the project outputs. These NED costs may differ from the expenses of constructing and maintaining the project. For coastal protection projects, expenses would include the first costs of project construction, any periodic nourishment and maintenance costs, and future rehabilitation costs.

548. The nature of future costs depends on the type of project. For instance, a structural type of project, e.g., a stone revetment, typically has high first costs and high future rehabilitation costs but low future maintenance costs. On the other hand, when compared to a hard structure project, a beach fill type project is composed of relatively low first costs, but larger recurring future maintenance costs (periodic nourishment).

549. Once the alternative formulated plans are evaluated in economic terms, the expected net benefits can be calculated. Following the project selection criteria in the P&G, the recommended type and scale of plan should be the one that reasonably maximizes net NED benefits. This is a key conceptual point in both the deterministic and risk analysis evaluation methodologies. Both methods apply the net benefits decision rule for selecting the economically optimal project.

550. SENSITIVITY ANALYSIS. Certain key parameters were varied to determine their effect on the economic analysis of Absecon Island.

551. Interest Rate. Project benefits and costs were annualized at higher discount rates of 8% and 10%. The results are displayed below in table 53.

Table 53

SENSITIVITY ANALYSES Discount Rate Change	
8% Discount rate:	
Average Annual Benefits:	
Storm Damage Reduction[1]	$8,914,000
Recreation	$6,963,000
Benefits During Construction	$501,400
Average Annual Benefits:	$16,378,400
Average Annual Costs[2]	$8,670,400
Benefit-Cost Ratio:	1.89
Net Benefits:	$7,708,000
10% Discount rate:	
Average Annual Benefits:	
Storm Damage Reduction	$8,914,000
Recreation	$6,963,000
Benefits During Construction	$624,800
Average Annual Benefits:	$16,501,800
Average Annual Costs:	$9,745,000
Benefit-Cost Ratio:	1.69
Net Benefits:	$6,756,800

[1] Includes reduced maintenance

[2] Includes operation, maintenance, and monitoring

552. Replacement Cost Values. The NED plan was also rerun changing the structure and content replacement values +/- 10 percent. The results are displayed below in table 54.

Table 54

SENSITIVITY ANALYSES Replacement Cost Value Change	
+10% Structure Replacement Cost:	
Average Annual Benefits:	
Storm Damage Reduction[3]	$9,622,000
Recreation	$6,963,000
Benefits During Construction	$479,000
Average Annual Benefits:	$17,064,000
Average Annual Costs[4]	$8,476,700
Benefit-Cost Ratio:	2.01
Net Benefits:	$8,587,300
-10% Structure Replacement Cost:	
Average Annual Benefits:	
Storm Damage Reduction	$8,344,000
Recreation	$6,963,000
Benefits During Construction	$479,000
Average Annual Benefits:	$15,786,000
Average Annual Costs:	$8,476,700
Benefit-Cost Ratio:	1.86
Net Benefits:	$7,309,300

[3]Includes reduced maintenance

[4]Includes operation, maintenance, and monitoring

553. Depth-Damage Curves. The NED plan was rerun changing the inundation depth-damage +/- 10 percent. The results are displayed below in Table 55.

Table 55

SENSITIVITY ANALYSES Depth-Damage Curves Change	
Depth-Damage Curves +10%:	
Average Annual Benefits:	
Storm Damage Reduction[3]	$9,338,000
Recreation	$6,963,000
Benefits During Construction	$479,000
Average Annual Benefits:	$16,780,000
Average Annual Costs[4]	$8,476,700
Benefit-Cost Ratio:	1.98
Net Benefits:	$8,303,300
Depth-Damage Curves -10%:	
Average Annual Benefits:	
Storm Damage Reduction	$8,508,000
Recreation	$6,963,000
Benefits During Construction	$479,000
Average Annual Benefits:	$15,950,000
Average Annual Costs:	$8,476,700
Benefit-Cost Ratio:	1.88
Net Benefits:	$7,473,300

[3] Includes reduced maintenance

[4] Includes operation, maintenance, and monitoring

LOCAL COOPERATION

554. COST APPORTIONMENT. The cost apportionment between Federal and non-Federal total first cost of the selected plan is shown in Table 56. The selected plan has been shown to be economically justified on benefits associated with storm damage reduction. There are no separable recreation features included with this project. Recreation benefits resulting from the selected plan are not required for justification. Therefore, all recreation benefits are assumed to be incidental to the project. In accordance with Section 103 of the Water Resources Development Act of 1986 and appropriate Federal regulations, such as ER 1165-2-130, Federal participation in a project formulated for hurricane and storm damage reduction is 65 percent of the estimated total project first costs, including Lands, Easements, Rights-of-Ways, Relocations and Dredged Material Disposal Areas (LERRD). LERRD fir this project includes the estimated administrative costs related to the obtainment of easements required for project construction ($107,728) and estimated costs for extensions of existing outfall pipes ($787,154). The estimated market value of LERRD provided by non-Federal interests is included in the total project cost, and they shall receive credit for the value of these contributions against the non-Federal cost share.

555. The cost sharing for the selected plan is based on a total first cost of $52,146,000, and does not include interest during construction, which is used only for economic justification purposes.

TABLE 56 COST SHARING FOR THE SELECTED PLAN (October 1995 price level)					
ITEM		**COST**			
INITIAL BEACH REPLENISHMENT AND BULKHEADS		$51,251,000			
LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, DISPOSAL AREAS (LERRD) (includes outfall extensions performed by non-Federal sponsor)		$895,000			
PERIODIC NOURISHMENT (3 year cycle)		$12,188,000			
PROJECT MONITORING (Annualized)		$268,000			
PROJECT FEATURE	FEDERAL COST	%	NON-FEDERAL COST	%	TOTAL
Initial Project Costs (Cash Contributions)	$33,313,150		$17,937,850		$51,251,000
LERRD	$0		$895,000		$895,000
Total Initial Project Costs	$33,313,150	65%	$18,832,850	35%	$52,146,000
Periodic Nourishment (50 Years) (includes major replacement costs)	$130,121,000	65%	$70,065,000	35%	$200,186,000
Project Monitoring Costs (50 years)	$8,530,600	65%	$4,593,400	35%	$13,124,000
Ultimate Project Cost (50 Years)	$172,964,750	65%	$93,491,250	35%	$265,456,000
Ultimate Project Cost Rounded (50 years)	$172,965,000	65%	$93,491,000	35%	$265,456,000

556. SPONSOR FINANCING. In accordance with Section 105(a)(1) of WRDA 1986, the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study was cost shared 50%-50% between the Federal Government and the State of New Jersey. The contributed funds of the local sponsor, the New Jersey Department of Environmental Protection (NJDEP) demonstrates their intent to

support a project for Absecon Island, New Jersey.

557. The State of New Jersey has a stable source of funding for shore protection projects as described in the Introduction of this report. The State has incorporated this project into its forecast of expenditures.

558. PROJECT COOPERATION AGREEMENT. A fully coordinated Project Cooperation Agreement (PCA) package (to include the Sponsor's financing plan) will be prepared subsequent to the approval of the feasibility phase and will reflect the recommendations of this Feasibility Study. NJDEP, the non-Federal sponsor, has indicated support of the recommendations presented in this Feasibility Study and the desire to execute a PCA for the recommended plan. Other non-Federal interests, such as the Cities of Atlantic City, Ventnor and Margate, the Borough of Longport and Atlantic County have indicated their support of the project.

559. In the PCA the non-Federal sponsor will:

- Provide 35 percent of total project costs assigned to hurricane and storm damage reduction, as further specified below:

- Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the Project.

- Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, wasteweirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

- Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to hurricane and storm damage reduction.

- For so long as the Project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed Project, or functional portion of the Project, at no cost to the Federal Government, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

- Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal Sponsor, now or hereafter, owns or controls for access to the Project for the purpose of inspection, and, if necessary after failure to perform by the Non-Federal Sponsor, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the Non-Federal Sponsor of responsibility to meet the Non-Federal Sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

- Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project and any Project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.

- Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20.

- Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the Non-Federal Sponsor with prior specific written direction, in which case the Non-Federal Sponsor shall perform such investigations in accordance with such written direction.

- Assume complete financial responsibility, as between the Federal Government and the Non-Federal Sponsor for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

- As between the Federal Government and the Non-Federal Sponsor, the Non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA.

- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

- Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army".

- Provide 35 percent of that portion of total historic preservation mitigation and data recovery costs attributable to hurricane and storm damage reduction that are in excess of one percent of the total amount authorized to be appropriated for hurricane and storm damage reduction.

- Participate in and comply with applicable Federal flood plain management and flood insurance programs.

- Not less than once each year inform affected interests of the extent of protection afforded by the Project.

- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the Project.

- For so long as the project remains authorized, the Non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based.

- Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

560. In an effort to keep the Sponsor involved and local governments informed, meetings were held throughout the feasibility phase. In addition, newsletters were sent periodically describing the study process for Absecon Island (see Appendix D).

561. Coordination efforts will continue, including coordination of this study with other State and Federal agencies. It is currently anticipated that a public meeting will be held upon approval of this Feasibility Study.

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FINAL
ENVIRONMENTAL IMPACT STATEMENT
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
FEASIBILITY STUDY
ABSECON ISLAND INTERIM STUDY
ATLANTIC COUNTY, NEW JERSEY

AUGUST 1996

Prepared by:
United States Army Corps of Engineers
Philadelphia District
Planning Division
Environmental Resources Branch
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

Final Environmental Impact Statement
Brigantine Inlet to Great Egg Harbor Inlet
Feasibility Study
Absecon Island Interim Study

The lead agency is the U.S. Army Corps of Engineers, Philadelphia District.

Abstract:

This study evaluates existing conditions and shore protection problems facing the communities on Absecon Island, along the Atlantic Coast of New Jersey. Significant beach and dune erosion has left the island vulnerable to storm damages. Severe storms in recent years have caused a reduction in the overall beach height and width along the study area, which, along with the absence of significant dunes, exposes the communities of Atlantic City, Longport, Ventnor, and Margate to catastrophic damage from ocean flooding and wave attack. The selected plan for storm damage reduction along the ocean front is beach nourishment utilizing sand obtained from 3 offshore borrow areas. Beach nourishment will consist of berm and dune restoration along the ocean frontage of Absecon Island. This plan will require 6.2 million cubic yards of sand for initial beachfill placement with 1,666,000 cubic yards for periodic renourishment every 3 years over a 50 year project life. The proposed beach nourishment will result in a 200 foot wide berm with a top elevation of +8.5 feet NGVD29 in Atlantic City, and a 100 foot wide berm with a top elevation of +8.5 feet NGVD29 in Ventnor, Margate, and Longport. The beachfill will be transitioned from a 200 foot berm to a 100 foot berm between Atlantic City and Ventnor for a distance of 1000 feet. In Margate, Longport, and Ventnor, dunes will also be constructed to a top elevation of +14 feet NGVD29, with a 25 foot top width, and side slopes of 1V:5H. The Atlantic City dune will have a top elevation of +16 feet NGVD29, top width of 25 feet, and side slopes of 1V:5H. The dunes are proposed to be planted with 91 acres of dune grass. The dunes will also contain 63,675 linear feet of sand fence, as well as pedestrian and vehicular access ramps.

The selected plan also includes the construction of two timber sheet-pile bulkheads along the Absecon Inlet frontage. The anchored bulkheads would tie in to the existing bulkhead located along Maine Avenue. The bulkheads would be constructed to a top elevation of +14 feet NGVD29, with pile anchors and tie-backs. A revetment of 3-5 ton rough quarrystone will be constructed to an elevation of +5 feet NGVD29 on the seaward side of the bulkhead.

A Section 404 (b)(1) evaluation has been prepared and is included in this Final Environmental Impact Statement. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Federal Clean Water Act.

PLEASE SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY:

For further information on this statement, please contact:
Beth Brandreth
Environmental Resources Branch
Telephone: (215) 656-6555

U.S. Army Corps of Engineers, Philadelphia District
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

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1.0 SUMMARY

1.1 PURPOSE AND NEED

The purpose and need of this statement is to evaluate the anticipated environmental impacts of the alternatives developed for storm damage reduction on Absecon Island, Atlantic County, New Jersey.

The need to which the U.S. Army Corps of Engineers, Philadelphia District is responding is based on the need to reduce the potential for storm damage to structures and property associated with the communities of Absecon Island, New Jersey.

The principal source of economic damages identified for Absecon Island are storms. Severe storms in recent years have caused a reduction in the overall beach height and width along the study area. This, as well as the absence of significant dunes, exposes Absecon Island to catastrophic damage from ocean flooding and wave attack.

1.2 BACKGROUND

The project location (Figure 1) is a segment of Atlantic Coast beach in southern New Jersey, and is approximately 8 miles in length, extending from Absecon Inlet to Great Egg Harbor Inlet. The study area encompasses Absecon Island, which is located in Atlantic County. Absecon Island contains the four communities of Atlantic City, Ventnor, Margate, and Longport. The beaches in these communities have been subject to erosion by storms, tidal inundation, and wave action. Within these areas, structural damage has occurred through direct wave action, particularly at those locations where at times there is virtually no remaining beach or dune system to protect the structures lining the shore.

Efforts have been made to remedy the problems of beach loss within the project area since the mid 1900's. These have included both numerous studies and actual construction. One early Federal beach erosion control project in the study area included the Atlantic City, NJ project which was adopted as House Document 81-538 in 1954. This project was partially completed before being deauthorized in 1990 by PL 99-662. The completed aspects of this project included the construction of 3727 feet of the Brigantine Jetty, some groin and bulkhead work, and beachfill.

Other studies have been conducted, but never constructed these studies examined widening the beachfront, groin

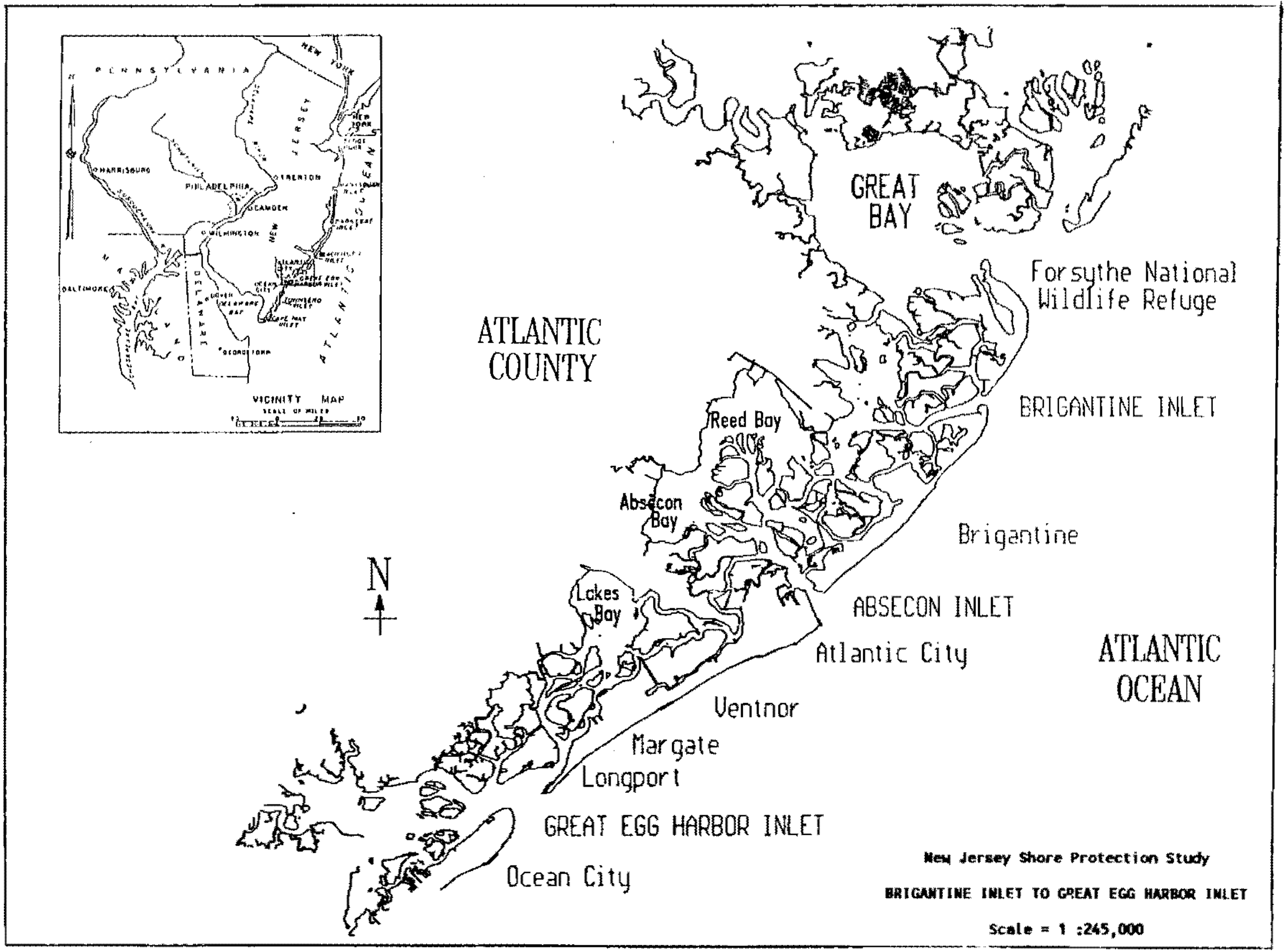

FIGURE 1. Brigantine Inlet to Great Egg Harbor Inlet Study Area

maintenance, dunes, and periodic nourishment. These studies, which were conducted during the time frame of the 1950's through the 1980's, covered the areas of Ventnor, Margate, and Longport, as well as Brigantine Island and Absecon Island. A list of federal activities in the project area is found in Table 1.

In addition to Federal acivities, the NJDEP has been involved in local shore protection along the coast of New Jersey. The Division of Coastal Resources provides technical assistance to citizens and municipalities. Further, it regulates land use through the Coastal Zone Facility Review Act (CFRA), the Wetlands Act, and the Waterfront Development Act.

Since 1985, the NJDEP has initiated several related projects in the study area. Many projects involve dredging of navigation channels and discharging the material on beaches or in back bays. All of the projects under the authority of the State are tailored to address specific small scale problems, and are therefore less expensive than Federal shore protection and navigation projects.

Table 2 describes recent state, municipal, and private projects within the study limits. The dates listed are the dates of permit approval from the U.S. Army Corps of Engineers.

1.3 ALTERNATIVES

A total of 17 structural and three non-structural alternatives have been considered to provide storm damage reduction to the project area. These alternatives were screened based on engineering, socio-economic, and environmental considerations. Excluding the no action alternative, the structural alternatives include seawalls, bulkheads, high profile breakwaters, groins, and beach nourishment. The screening and final optimization concluded that beach nourishment utilizing material dredged from a nearby source should be considered further for the ocean front. Bulkheads were chosen for the inlet frontage. The details of the preferred ocean front plan, the beach nourishment alternative, are as follows: Beach nourishment will consist of berm and dune restoration along the ocean frontage of Absecon Island. This plan will require 6.2 million cubic yards of sand for initial beachfill placement, with 1,666,000 cubic yards for periodic renourishment every 3 years, over a 50 year project life. The proposed beach nourishment will result in a 200 foot wide berm with a top elevation of +8.5 NGVD in Atlantic City, and a 100 foot wide berm with a top elevation of +8.5 NGVD in Ventnor, Margate, and Longport. The beachfill will be transitioned from a 200 foot berm to a 100 foot berm between Atlantic City and Ventnor for a distance of 1000 feet. In Ventnor, Margate, and Longport, dunes will also be constructed to a top elevation of +14 feet NGVD, with a 25 foot top width, and side slopes of 1V:5H. In Atlantic City, the dune will have a

TABLE 1
PRIOR FEDERAL ACTIONS
BRIGANTINE INLET TO GREAT EGG HARBOR INLET

AGENCY	LOCATION	AUTHORIZATION	DESCRIPTION OF PROJECT/STUDY	STATUS
USACE	Brigantine Inlet to Great Egg Harbor Inlet	Senate and House Resolutions December 1987	Shore Protection and Water Quality Study	Reconnaissance Study Report February, 1992
USACE	Coast of New Jersey, Sandy Hook to Cape May	Senate and House Resolutions December 1987	Shore Protection and Water Quality Study	Limited Reconnaissance Study Report September, 1990
USACE	Brigantine Island	HD 94-631 SEC 101a-WRDA 1976 SEC 605-WRDA 1986	Reimburse State for 7 groins Construct new groin Construct dune with fence & grass Raise beach Extend groin Maintain existing groins Periodic nourishment	Preconstruction Planning/Engineering funds never appropriated.
USACE	Absecon Island	HD 94-631 SEC 101a-WRDA 1976 SEC 605-WRDA 1986	Construct weir breakwater for sand bypassing Initial nourishment of beaches Periodic nourishment of beaches	Preconstruction Planning/Engineering funds never appropriated.
USACE	Ventnor, Margate, Longport	PL 86-645. Modified PL 87-874, 1962	Widen beach by placement of fill Maintenance of one existing groin Periodic nourishment	Deauthorized 1 Jan 90 by PL99-662
USACE	Atlantic City	HD 81-538 of 1954 HD 88-325 of 1962	Inlet frontage seawall New groins and extensions Beachfill and Periodic nourishment	Deauthorized 1 Jan 90 by PL99-662
USACE	Absecon Inlet Clam Creek	HD 67-375 of 1922 HD 76-504 of 1946	Provide entrance channel	Completed 1957; Last maintenance dredging 1978 Clam Creek dredged 1983

TA[illegible] 2
PRIOR NON-[illegible]L PROJECTS
ABSECON INLET TO G[illegible] EGG HARBOR INLET

AGENCY	COASTAL AREA	LOCATION	NATURE OF PROJECT	DATE OF REGULATORY APPROVAL
NJDEP	Absecon Inlet	Absecon Inlet/Atlantic Ocean	Dredging	04/11/85
NJDEP	Absecon	Absecon Creek & Absecon Bay	Maintenance Dredge	12/03/87
NJDEP	Atlantic City	Oriental Avenue - Arkansas	Beach Nourishment	04/01/86
NJDEP	Longport	11th to 25th Avenue	Dredge Great Egg Harbor Inlet. Place sand on Longport beaches.	05/22/90
NJDEP	Longport	11th to Atlantic	Stone Revetment	09/24/93
Municipal	Atlantic City	Atlantic to Madison and Melrose to Caspian	Bulkhead reconstruction with riprap toe protection	1993
Municipal	Longport	Vicinity of 17th Street	Stone revetment along Risley Channel	N/A
Private	Atlantic City	Clam Creek	Dredging	05/09/88
Private	Atlantic City	Clam Creek & 801 N. Maryland Avenue	Dredging	12/29/89
Private	Atlantic City	Beach Thorofare along 2923 Sunset Avenue	Dredge and construct bulkhead.	10/09/85
Private	Atlantic City	Clam Creek at Huron, MD and RI Avenues	Dredging	01/11/88
Private	Atlantic City	Gardener's Basin at 320 N. RI Avenue	Replace bulkhead and fill.	12/29/87
Private	Atlantic City	Missouri Ave. Generating Station	Construction of bulkhead & revetment.	07/24/91
Private	Atlantic City	Beach Thorofare	Wooden pier and riprap	05/21/90
Private	Margate	Beach Thorofare & Amherst Ave.	Dredge & construct marina	01/19/88
Private	Margate	Beach Thorofare & Amherst Ave.	Dredge & construct marina	02/05/91
Private	Ventnor	Block 157, Lot 17	Reconstruct marina. Increase boat slips.	04/12/90
Private	Ventnor	West Canal, 714 North Harvard Ave.	Construct piers, moorings, and maintenance dredge.	06/28/90
Private	Ventnor	West Canal & IWW, North Harvard Ave.	Dredge and construct piers.	06/13/88

top elevation of +16 feet NGVD29, a 25 foot top width, and side slopes of 1V:5H. The dunes are proposed to be planted with 91 acres of dune grass. The dune will also contain 63,675 linear feet of sand fence, as well as 170 pedestrian and 10 vehicular crossovers.

The preferred plan for the project area also consists of the construction of a timber sheet-pile bulkhead in two separate sections along approximately 1,050 feet of the Absecon Inlet frontage. The anchored timber sheet-pile bulkhead would tie in to the existing bulkhead constructed along Maine Avenue at both locations. From Atlantic to Oriental Avenues, the bulkhead would be located at the seaward edge of the existing boardwalk. Both sections of bulkhead would be constructed to a top elevation of +14 NGVD29, with pile anchors and tie-backs. A revetment of 3-5 ton rough quarrystone will be constructed to an elevation of +5 NGVD29 on the seaward side of the bulkhead. This bulkhead would prevent damages from inundation and wave attack.

1.4 MAJOR CONCLUSIONS AND FINDINGS

Beach nourishment represents the least environmentally damaging structural method of reducing potential storm damages at a reasonable cost. It is socially acceptable, and proven to work in high energy environments. The somewhat transient nature of beach nourishment is actually advantageous. Beach fill is dynamic, and adjusts to changing conditions until equilibrium can again be achieved. Despite being structurally flexible, the created beach can effectively dissipate high storm energies, although at its own expense. Costly rigid structures like seawalls and breakwaters utilize massive amounts of material foreign to the existing environment to absorb the force of waves. Beach nourishment uses material typical of adjacent areas, sand, to buffer the shoreline structures against storm damage. Consequently, beach nourishment is more aesthetically pleasing as it represents the smallest departure from existing conditions in a visual and physical sense, unlike groins. When the protective beach is totally dispersed by wave action, the original beach remains. On the other hand, bulkheads, seawalls, and revetments may lead instead to eventual loss of beach as the end of their project life is approached.

Some of the suggested non-structural storm damage reduction alternatives are currently practiced, such as flood insurance and development regulation. Consequently, implementation is somewhat a moot point. Others such as land acquisition are prohibitively expensive, and are socially unacceptable in any event.

1.5 AREAS OF CONCERN

A project of this nature will have temporary adverse impacts on water quality and aquatic organisms. Dredging will increase suspended solids and turbidity at the point of dredging and at the discharge (beachfill) site. The area to be dredged and the area where the material will be deposited will be subject to extreme disturbance. Many existing benthic organisms will become smothered at the beachfill site. Dredging will result in the temporary complete loss of the benthic community in the borrow area. These disruptions are expected to be of short-duration and of minor significance if rapid recolonization by the benthic community occurs. Dredging will consequently temporarily displace a food source for some finfish.

Absecon Inlet, Great Egg Harbor Inlet, and the offshore area, where the propsed borrow areas are located, has historically been a productive surf clam (Spisula solidissima) fishery. Recent surveys conducted within the proposed borrow areas indicate that these areas are still suitable for surf clam harvesting. Dredging in these areas has the potential to remove the harvestable clams. In addition, periodic maintenance disturbances subsequent to the initial dredging may have adverse effects on any potential recovery of the surf clam population. Where ever possible, measures will be taken to minimize the impacts to the surf clam population within the borrow areas. These measures may include the commercial harvesting of clams prior to dredging, only dredging in approved sections of the borrow areas, and limiting the number of sites used for renourishment activities. These and any other measures will be fully coordinated with appropriate state and local resource agencies.

Concerns regarding the use of a hopper dredge and its potential impact on Federally listed threatened and endangered sea turtles were raised with respect to this project. A biological assessment, pursuant to Section 7 of the Endangered Species Act, is currently being reviewed by the National Marine Fisheries Service (NMFS). This assessment covers all Philadelphia District dredging projects that may have an impact on threatened and endangered marine species. Until a final biological opinion is received from NMFS, the Philadelphia District will continue the measures used in the past to reduce the likelihood of negatively impacting marine species. These measures may include the use of NMFS approved turtle monitors, dragarm deflectors on the dredge, and timing the dredging when sea turtles are known to be absent in the borrow area. These and any other measures will be fully coordinated with NMFS prior to dredging.

Concern over the impact of a beachfill operation on the State and Federally threatened piping plover has been raised with regard to this project. Piping plovers generally nest between April and August on sparsely vegetated, sandy beaches in New Jersey. While plovers have been known to nest on the southern tip of Brigantine Island, no nesting pairs have been observed on Absecon Island. If a nesting pair(s) should appear within the project impact area prior to or during the initial beachfill and subsequent periodic beach nourishments, appropriate measures to avoid adversely impacting these and other threatened or endangered birds will be implemented. Mitigative measures will be coordinated with the U.S. Fish and Wildlife Service and the New Jersey Department of Environmental Protection (NJDEP), Division of Fish, Game and Wildlife. These measures may include the establishment of buffer zones around discovered nests, and conducting beachfill operations around the buffer zone until nesting is completed.

1.6 ENVIRONMENTAL STATUTES AND REQUIREMENTS

Preparation of this Final Environmental Impact Statement (FEIS) has included coordination with appropriate Federal and State resource agencies. With the public review of the DEIS, a Water Quality Certificate, in accordance with Section 401 of the Clean Water Act, and a concurrence of Federal consistency with the New Jersey Coastal Zone Management program, in accordance with Section 307(c) of the Coastal Zone Management Act, was requested from the New Jersey Department of Environmental Protection (NJDEP). NJDEP has responded to this request and coordination is currently taking place to resolve their concerns regarding the project. The Corps feels that mutually agreeable solutions will result from this coordination and that a Water Quality Certificate and Coastal Zone consistency will be forthcoming. The Comment/Response Appendix of this report contains the comment letter from NJDEP as well as the Corps responses to their concerns. A Section 404(b) (1) evaluation has been prepared and is included as Section 7 of the FEIS. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Clean Water Act. In accordance with the Fish and Wildlife Coordination Act (FWCA), planning aid reports were obtained and are provided in the Pertinent Correspondence Appendix in the main report. A section 2(b) FWCA report was obtained, based on information presented in the DEIS. The section 2(b) report can be found in the Comment/Response Appendix in the main report.

Compliance was met for all environmental quality statutes and environmental review requirements except the Clean Water Act and Coastal Zone Management Act. Coordination is continuing with the NJDEP regarding these Acts and compliance certification is expected. Table 3 provides a list of Federal environmental quality statutes applicable to this statement, and their

Table 3. Compliance with Environmental Quality Protection Statutes and Other Environmental Review Requirements at the Present Phase of the Project.

Federal Statutes	Compliance w/Proposed Plan
Archeological - Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	Conditional
Coastal Zone Management Act of 1972, as amended	Conditional
Endangered Species Act of 1973, as amended	Full
Estuary Protection Act	Full
Federal Water Project Recreation Act, as amended	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act, as amended	N/A
Marine Protection, Research and Sanctuaries Act	Full
National Historic Preservation Act of 1966, as amended	Full
National Environmental Policy Act, as amended	Full
Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic River Act	N/A
Coastal Barrier Resources Act	N/A

Table 3. Compliance with Environmental Quality Protection Statutes and Other Environmental Review Requirements (concluded)

Executive Orders, Memorandum, etc.	
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO 12114 Environmental Effects of Major Federal Actions	Full

Full Compliance - Requirements of the statute, EO, or other environmental requirements are met for the current stage of review.

Conditional Compliance - NJDEP has issued a conditional compliance for the project based on the resolution of items discussed in their August 26, 1996 letter (See first page of comment/response appendix).

Noncompliance - None of the requirements of the statute, EO, or other policy and related regulations have been met.

N/A - Statute, EO, or other policy and related regulations are not applicable.

Ongoing - Coordination is continuing.

compliance status relative to the current stage of project review.

2.0 NEED FOR AND OBJECTIVE OF ACTION

2.1 NEED

The proposed action is based on a need for storm damage reduction which would benefit the communities on Absecon Island. The need for storm damage reduction action is based on storm damage vulnerability with a high potential for storm-induced erosion, inundation and wave attack, which is exacerbated by long term shoreline erosion.

The principal problems identified along Absecon Island are progressive beach erosion due to long-term shore processes, and the threat of storm damage. This reach of the New Jersey shoreline was one of the earliest to be developed, and therefore has been subject to storm damages for a long time. The Longport seawall was built in 1917 after the loss of the southernmost ten blocks of the community. Strides have been made in some areas to minimize losses associated with storm damage. Such advances include building code improvements, dune ordinances and building restrictions. Many portions of the developed coast will remain vulnerable however, due to the proximity of structures to the beach and the level of development.

Progressive and constant erosion is evident in certain areas of the coastline. This erosion slowly narrows the protective beach width. Atlantic City's northern shoulder has long term erosion rates of between 2.5 and 7 feet per year.

It should be noted that simply because areas may have relatively stable or low background erosion rates does not preclude the need to fully address options for additional shore protection. Ventnor and Margate have relatively wide beaches in some areas but the dunes are small and discontinuous. Nor does a stable historic erosion rate mean that over the course of several years shoreline positions and elevations do not vary greatly. For example Longport, which has a relatively stable shoreline position due to its seawall, lost a great deal of beach elevation during the recent storms of 1991 and 1992. A lower beach elevation will allow larger waves to impact the oceanfront. The beach elevation regained in subsequent years, presumably concurrent with a loss of sand in the northern beaches. Presently, much of the existing beachfront in Longport lacks an adequate dune system and the berm width is zero in front of the seawall.

The principal cause of economic damages identified along the Atlantic coast of New Jersey is storms. An accurate assessment of storm damages, delineated by causal mechanism, is difficult to develop for coastal storms. Along the study area, records of historic storm damages are poor except for the 1962 Northeaster, the coastal storm of 1984 and the December 1992 storm. The years 1991-1992 brought three significant storms to the study area. A summary of existing storm damage information for the study area is presented in Table 4.

Over the years, erosion and storm activity have seriously reduced the ability of the shoreline in the project area to provide adequate storm damage protection for Absecon Island. Continuation of this historic trend will increase the potential for economic losses, and the threat to human life and safety.

2.2 OBJECTIVES

Planning objectives were identified based on problems, needs and opportunities, as well as existing physical and environmental conditions present in the study area.

In general, the prime Federal objective is to contribute to the National Economic Development (NED) account consistent with protecting the Nation's environment. Both of these objectives must be consistent with national legal statutes, applicable executive orders, and other Federal planning requirements. The general and specific planning objectives for the Absecon Island Interim Feasibility Study take an integrated systematic approach to the solution of the erosion and inundation problems associated with coastal storms on Absecon Island. Accordingly, the following general and specific objectives have been identified.

General:

- Meet the specified needs and concerns of the general public.
- Respond to expressed public desires and preferences.
- Be flexible to accommodate changing economic, social and environmental patterns and changing technologies.
- Integrate with and be complementary to other related programs in the study area.
- Be implementable with respect to financial and institutional capabilities and public support.

Specific:

- Reduce the threat of potential future damages due to the effects of storms, with an emphasis on inundation and recession of the shoreline.

TABLE 4

HISTORIC STORM DAMAGE DATA

DATE	DAMAGES	NOTES
9/1889	$50,000 (1889 $)	Heinz Pier, Atlantic City
10/1896	$33,000 (1896 $)	Atlantic City
9/38	$70,000 (1938 $)	Brigantine to Atlantic City
9/44	$5,000,000 (1944 $) $1,000,000 (1944 $)	Atlantic City; 62% attributable to wave damage. Ventnor, Margate, Longport
11/50	$564,000 (1950$) $100,000 (1950$)	Absecon Island Longport
3/62	$21,634,700 (1962 $)	Absecon Island; 10% attributable to wave action
3/84	$1,450,325 (1984 $)	Atlantic County
10/91	$13,000,000	Atlantic County (initial amount claimed by County)
1/92	$2,650,000	Absecon Island (NJDEP estimate to repair beaches only)
12/92	$1,183,854 $ 259,405 $ 437,070 $ 125,199 $2,600,000	Atlantic City Ventnor Margate Longport Atlantic County (FEMA Qualified Damage)

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- Mitigate the effects of, or prevent, the long-term erosion that is now being experienced.

- In accordance with the limits of institutional participation, all plan components must maximize NED benefits.

- Enhance the recreational potential of the area as an incidental benefit.

- Where possible, preserve and maintain the environmental character of the areas under study, including such considerations as aesthetic, environmental and social concerns, as directly related to plans formulated for implementation by the Corps.

2.3 PROJECT AUTHORITY

The Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U. S. Senate in December 1987.

The Senate resolution adopted by the Committee on Environment and Pubic Works on December 17, 1987 states:

> "That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hearby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be

undertaken in areas identified as having potential for a Federal project, action, or response".

The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

> "That the Board of Engineers for Rivers and Harbors is hearby requested to review existing reports for the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, the development of recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution form existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response which is engineeringly, economically, and environmentally feasible".

2.4 PUBLIC CONCERNS

Initial discussions with local, State, and Federal agencies produced the following concerns that were either environmental or socio-economic in nature.

The non-Federal sponsor for this Feasibility study is the New Jersey Department of Environmental Protection (NJDEP). Currently, NJDEP's concern, within the scope of this interim feasibility study, is with shore protection problems on Absecon Island. The State is interested in a long-term Federal shore protection project due to funding constraints, which prohibit the State and local governments from carrying out a long term shore protection program on their own.

Selection of a sand borrow area(s) was a primary environmental concern raised for this project. Issues involved with borrow area selection included the presence/absence of significant cultural resources, benthic resources, surf clam stocks, fisheries impacts, threatened and endangered species, water quality impacts, and sand grain compatibilities with beach material. Some of these issues required further investigation and are discussed in later sections of this FEIS.

3.0 ALTERNATIVES

3.1 SCREENING OF ALTERNATIVES

3.1.1 Structural Storm Damage Reduction Alternatives

3.1.1.1 Bulkheads

The bulkheads protecting Absecon Island, both along the inlet and the ocean front, are constructed of timber and concrete, and conditions vary from excellent to poor. The top elevation of the bulkheads vary between +10 to +15.5 feet MLW along the Absecon Inlet frontage, where there are two different sections of bulkhead. The new anchored bulkhead along Maine Avenue from Caspian Avenue to Atlantic Avenue (2200 feet in length), was constructed in 1993 and is in excellent condition. The remaining sections from Atlantic to Euclid Avenues (300 feet in length), and those from Seaside to Metropolitan Avenues (approximately 1000 feet in length), were constructed in 1935 and are in very poor condition. The section from Seaside to Metropolitan is buried under sand, and is discontinuous in many areas.

In Ventnor, all timber and concrete bulkheads were constructed by private interests. There is 5300 feet of concrete bulkhead and 3400 feet of timber bulkhead in the city of Ventnor. All the concrete bulkheads were constructed between 1925 and 1935, top elevations vary between +12 to +13 feet MLW, top widths vary between 2 and 3 feet, and conditions range from poor to good. All the concrete bulkheads are mostly intact and continue to provide protection to beachfront properties and street ends. The timber bulkheads in Ventnor were constructed between 1950 and 1952, with approximately 500 feet being replaced following the March 1962 storm.

In Margate, the entire shorefront (8450 feet) is protected by timber bulkheads, which were built between 1957 and 1964. The newest sections of bulkhead at Granville and Rumson Avenues were replaced in 1993. Top elevations vary between +10 and +13 feet MLW, and the majority are in fair to good condition.

In Longport, most of the ocean front is protected by either timber bulkhead or curved-face concrete seawall. There is also 55 feet of steel sheet pile bulkhead at the seaward end of

28th Avenue which is in poor condition with significant corrosion. The timber bulkheads vary in top elevation from +10 to +14 feet MLW and the majority are in fair to good condition. The most recent section replaced was at 30th Avenue and the property just north of 30th, in 1984. The sections at Pelham, Manor, and 31st Avenues are scheduled to be replaced in the near future by the State and municipality.

Bulkheads serve the purpose of stabilizing the upland behind them, as well as protecting the upland against wave action. Bulkheads can be characterized as an erosion control measure not designed to stand up to direct wave attack in ocean exposed locations. They do not provide a long-term solution, because a more substantial wall is required as the beach continues to recede, and larger waves reach the structure. In addition, vertical bulkheads can suffer from severe scouring when toe protection is not provided.

3.1.1.2 Seawalls

This alternative includes the construction of a "Longport type" curved face seawall placed along the entire project length, replacing all existing discontinuous and dilapidated bulkheads. This structure includes stone toe protection, is pile supported, and provided with underlying sheeting to reduce underseepage. This alternative would not provide any recreational beach restoration, but would provide storm damage protection consistent with other structural alternatives. The major problem with this alternative is its expense.

Seawalls may retain a low fill, but their primary purpose is to withstand, and to deflect or dissipate, wave energy on an ocean shoreline. Cost of construction would be prohibitively high with values of thousands of dollars per linear foot, depending on the size and construction material used. Because seawalls protect only the land immediately behind them, maintenance of a beach would be difficult. Also, scouring in front of the seawall and increased erosion can be expected during storms due to the reflection of waves. Widening and maintenance of the beach in front of the structure would be necessary to reduce scour, and to continue recreational use of the shoreline.

Currently, approximately 3300 feet of concrete seawall exists in the Longport section of the study area. The seawall is a combination curved face and stepped structure, which was originally built in 1917 and rehabilitated in 1981, at which time the curved face was repaired and the top elevation was raised to +11.6 feet MLW. The seawall is in fair to good condition, with some minor cracking and spalling. The structure has remained stable since 1963, and has been effective in providing protection to the properties behind it.

3.1.1.3 Revetments

There are three stone revetments providing erosion protection for bulkheads and seawalls on Absecon Island. There is a new stone revetment along the length of the new timber bulkhead at Maine Avenue on the Absecon Inlet frontage. There is also a stone revetment providing erosion protection along the length of the combination curved face and stepped reinforced concrete seawall in the city of Longport. Top elevation of the revetment varies between +6 to +6.3 feet MLW, and has concrete void filler in the upper 18 inches of stone. It is in fair to good condition.

There is a new stone revetment in the city of Longport at 11th Avenue, extending to the inner end of the stone groin constructed at Atlantic Avenue. The crest of the revetment was constructed with a top width of 14 feet, a top elevation of +8.0 feet MLW, using 8 to 9 ton weight rough quarrystone. The revetment fronts an existing timber bulkhead with a top elevation varying between +10.0 and +12.0 feet MLW, and replaces a previous concrete block and stone revetment. The revetment was constructed by the State of New Jersey in 1993.

Revetments are also similar in nature and construction to seawalls, however, they are typically sloped structures along a beach, dune, or bluff. Revetments, like seawalls, are designed to stand up to and dissipate wave energy. Revetments depend on the underlying soil for support; therefore, there is a vulnerability to damage and failure due to undermining.

3.1.1.4 Offshore Breakwater

Breakwaters have the effect of reducing wave action and acting as a littoral barrier that tends to build the shoreline leeward of them. Offshore breakwaters can range from floating tire or inflated structures placed in shallow water, to massive stone structures founded in relatively deep water. Particular care must be taken in the design and location of the structure, as erosion of the downdrift beach can occur if the structure is placed too near the shore, thus cutting off some of the littoral drift. Gaps or breaks in the structure must also be permitted to prevent the development of undesirable hydraulic currents between the ends of the structures, and to maintain water quality inshore of the structure. To be of material benefit, such a structure would have to be as long as the shoreline that is protected. Some advantages of breakwaters are that they provide protection without impairing the usefulness of the beach, and they have a relatively low maintenance cost and long project life. Some disadvantages are high construction costs, a potential navigation hazard, and a potential for starvation and erosion of downdrift beaches. Moreover, the reduction of wave action may have a negative impact on the attractiveness of the recreational beach.

3.1.1.5 Groins

There are currently eight (8) groins, approximately 500 feet apart, in Atlantic City along the Absecon Inlet frontage. Two timber groins were constructed by the city and State in 1930-32, and repaired and protected with stone ends in 1958. Five stone groins, and one timber and stone groin, were also constructed along the inlet by the city and State between 1946 and 1958. Also along the inlet in Atlantic City is the Oriental Avenue jetty. It was built by the Federal Government in 1946-48, extended in 1961-62 to its present length, and rehabilitated by the State in 1983. All eight inlet groins and the jetty are in good condition.

Along the ocean coast of Absecon Island, there are a total of twenty-nine (29) beach groins. Nine are stone groins that are in good to fair condition, with little or negligible displacement or loss of stone along their visible length. Several of the stone groins in Atlantic City were rehabilitated by the city and the State in 1983. Eleven beach groins are constructed of timber that are in fair to poor condition, many with rotting timbers which render them permeable. There are nine groins constructed of stone and timber cribbing that are in poor condition, with all but a few cases existing in a state of debris, nearly invisible. These do not appear to serve their original function, and similar structures have not been constructed since the late 1920's.

Groins are long, narrow structures, constructed perpendicular to the shoreline for the purpose of building or stabilizing the beach by trapping littoral material, or retaining artificially placed beachfill. In order for a system of groins to be effective, there must exist an adequate longshore movement of sand, and groins must be designed consistent with beach profiles. Otherwise downdrift groin compartments may not fill properly, and periodic artificial filling of groin compartments may be required. Groins, if not filled initially, tend to accumulate material on the updrift side, with a corresponding erosion of material on the downdrift side. The resulting irregularly shaped shoreline, together with the presence of the groin structures themselves, make groin-protected shorelines aesthetically displeasing to some individuals.

3.1.1.6 Beach Nourishment

Beach nourishment is moderate in cost in comparison to other structural alternatives, and directly solves the main erosion problem in the area, a deficiency of sand on the beach. An increase in beach area has an added benefit as a recreational feature, as well as aesthetically improving the appearance of the shoreline. In addition, a beach maintained in adequate dimensions has value as a protective measure because beaches are very effective in dissipating wave energy. An important feature of a successful and moderately priced beach nourishment project is to find a suitable borrow area, both in terms of the amount and grain size of the material to be used. A large enough dune height and berm width could provide a solution to all of the erosion and storm protection problems of the study area, but the cost to maintain an adequate berm width could be high.

3.1.1.7 Perched Beach

This alternative provides protection similar to beach restoration with an offshore breakwater. The difference is the addition of a submerged stone rubble mound structure, which is used to support the offshore end of the placed beachfill, thus eliminating the outer part of beach profile near its closure with the ocean bottom. Therefore, the actual amount of fill material to be placed is less than in a typical beachfill. The submerged rubble mound structure acts in the same way as the natural bar formed offshore during storm events, creating a "perched beach" with a wider berm. The main problem with this alternaitive is that the angled swell scours in front of, and behind the offshore structure, resulting in the need for heavy maintenance. In addition, any interception of littoral drift will cause erosion downcoast, even if only temporarily. Due to the expense caused by high maintenance with reclamation, this alternative was not considered further as part of the selected plan.

3.1.1.8 Submerged Reef With Beachfill

Another sand retention alternative, this alternative involves the use of interlocking concrete units which form an offshore reef. This reef is intended to dissipate incident wave energy during storms, and to prevent outgoing currents from carrying sand to deeper water. Experience to date with this alternative along the New Jersey shore does not indicate that it is cost effective.

3.1.1.9 Offshore Submerged Feeder Berm

Potentially high costs associated with onshore sand placement of sand have led to the development of alternate less expensive methods of beach nourishment. One such method is nearshore berm placement. In some areas, nearshore berms can reduce wave damage and provide sand to the littoral system with a cost as little as half that of onshore placement (Allison and Pollock, 1993 and McLellan et. al, 1990).

Because nearshore sand placement has not been successful in the past, and current design techniques are limited, nearshore placement is a higher risk option than direct onshore placement at Absecon Island. Also, because nourishment areas are located adjacent to potential borrow sources, the difference in cost between direct onshore and nearshore placement may not be significant.

3.1.2 Non-Structural Storm Damage Reduction Alternatives

3.1.2.1 Flood Insurance

Flood Insurance provides compensation for damages through annual premiums which are based on the risk involved. The National Flood Insurance Program encourages local governments to adopt sound flood plain management programs designed to reduce future flood losses.

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency (FEMA) as the base flood for purposes of flood plain management.

The Corps has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones. (See U.S. Army Corps of Engineers, Galveston District, Guidelines for Identifying Coastal High Hazard Zones, Galveston, Texas, June 1975.) These high energy wave zones, known as V zones, require much more stringent flood plain management measures, such as elevating structures on piles or piers.

The most recent studies completed by FEMA for the Cities of Atlantic City (15 February 1983), Margate City (18 April 1983), Ventnor (15 March 1983) and the Borough of Longport (15 February 1983) divided the coastal portions of the towns of Absecon Island into three zones:

> Zones V - Special Flood Hazard Areas along coasts inundated by the 100-year flood as determined by detailed methods, and that have additional hazards due to velocity (wave action); base flood elevations shown and flood hazard factors determined;
>
> Zones A - Special Flood Hazard Areas inundated by the 100-year flood; base flood elevations and flood hazards factors determined; and
>
> Zone B - Areas between limits of the 100-year flood and 500-year flood: or certain areas subject to 100-year flooding with average depths less than (1) one foot, or where the contributing drainage area is less than one square mile.

It should be noted that during the updated and detailed feasibility study, wave and inundation extent due to a 100 year storm event can vary considerably, when compared to the V zones delineated in the Federal Insurance Rate Maps (FIRMs).

Atlantic City is made up of three zones, V, A and B. The V zone generally extends along the coast and reaches landward, where it meets the coastal bulkheads and seawalls associated with the boardwalk from Jackson Avenue through Maine Avenue. The V zone continues parallel to Maine Avenue extending into the bay side of Atlantic City. Beyond the V zone the area becomes an A zone with the exception of a few B zone pockets, which occur between Jackson and Providence Avenues (approximately 400-800 feet wide), and also between Mission and Kentucky, and Tennessee and Virginia Avenues, 800 to 1000 feet landward of the boardwalk.

Longport's corporate limits have been designated as containing both V and A zones. The V zone generally ends at the beginning of the seawall. At the southeastern portion of Longport the V zone is within 40 to 80 feet of Beach Terrace. Gradually it recedes, and at 22nd and Atlantic Avenues it is approximately 240 feet seaward. At 32nd thru 36th Avenues the V zone fluctuates, but on average is 160 feet seaward of Atlantic Avenue. The flood zone beyond the V zone is designated A zone, which encompasses the rest of the borough.

In Margate, the V zone extends landward to the coastal bulkhead and slightly beyond in some areas. Generally the V zone is 400 feet east of Atlantic Avenue between Huntington and Cedargrove Avenues, the central coastline of Margate. The V zone edges closer to Atlantic Avenue north and south of this central area. There is an abrupt drop to a B zone near the northern corporate limits at Brunswick Avenue. The remainder of Margate is designated Zone A.

Ventnor also contains V, A and B zones. The V zone extends just beyond the boardwalk at points north from New Haven Avenue to the Ventnor City corporate limits. The bulkhead area where the V zone ends is 400 to 480 feet seaward of Atlantic Avenue. South of New Haven Avenue the V zone extends beyond the boardwalk approximately 40 to 160 feet, and continues to the southern limits of Ventnor. Beyond the V zone, the A zone begins. The A zone is quite narrow (40 to 80 feet) south of Derby Place. North of Derby Place, the A zone widens from approximately 40 to 120 feet. The A zone drops to a B zone, which extends north to south for the entire corporate limits, with a width of 800 feet. Beyond the B zone, the area reverts back to an A zone designation.

3.1.2.2 Development Regulations

This includes such non-structural measures as zoning, building codes, and bulkhead ordinances. Property owners who wish to develop or rehabilitate structures in the cities of Atlantic City, Margate, Ventnor or the Borough of Longport must first receive the proper permits from the New Jersey Department of Environmental Protection (NJDEP). NJDEP helps the applicant arrange meetings with appropriate State officials as well as answer any questions on permit requirements.

The Basic Building Code of the Building Officials and Code Administrators International, Inc. (BOCA) has been adopted as a Uniform Construction Code (N.J.S.A. 52:27D-1 et seq.) and is required for use by all municipalities in New Jersey. Flood proofing requirements were made part of the code in 1984. The flood proofing section of the code (Section 1313) applies to all new structures located in flood prone areas, and to those structures where damage or cost of reconstruction or restoration is in excess of 50% of its replacement value. Flood prone areas are defined using the 100 year base flood as the minimum criterion. The code requires that all buildings and structures located within a flood prone area have the lowest structural member, except pilings and columns, at or above the base flood level. The flood proofing requirements of the code in coastal high hazard areas ("V" Zone) pertain to anchoring of buildings and structures to piles and columns, fastening of building components, and placement of obstructions below the lowest floor. Pile foundations are either constructied of wood, concrete or steel columns driven into the soil. The BOCA code requires pilings to be used in the foundation of buildings for certain soil types, not proximity to the ocean as might be supposed.

Rules on Coastal Zone Management, N.J.A.C. 7:7E as amended July 18, 1994, also regard areas within 24 feet of oceanfront shore protection structures, which are subject to wave run-up and overtopping as part of High Hazard Areas. The Coastal High Hazard Area extends from offshore to the inland limit of a primary frontal dune along an open coast. V zones on many Federal Insurance Rate Maps (FIRMs) have landward limits in high hazard areas delineated by oceanfront bulkheads, revetments or seawalls, which are typical of the conditions for this study area.

Residential development, including hotels and motels is prohibited in coastal high hazard areas, except for single family and duplex infill developments, which are conditionally acceptable provided that the standards of New Jersey's coastal zone acts are met.

Generally, commercial development is discouraged in coastal high hazard areas. Some commercial development on the beach is conditionally acceptable within V zone areas provided the area already is densely developed, the site is landward of the boardwalk, the building size meets specific requirements, the facility is open to the general public and supports beach /tourism related activities, and the facility complies with all the flood proofing requirements stated in Rule on Coastal Zone Management N.J.A.C. 7:7E.

Development regulations are an effective means of controlling unwise development in coastal areas. Unfortunately, development regulations cannot prevent storm damages to existing structures within the project area.

3.1.2.3 Evacuation From Areas Subject to Erosion and Storm Damage

Permanent evacuation of existing developed areas subject to inundation involves the acquisition of lands and structures, either by purchase or through the exercise of powers of eminent domain, if necessary. Following this action, all commercial, industrial, and residential property in areas subject to erosion are either demolished or relocated to another site. High rise condominiums, hotels and casinos with their ancillary parking lots and support industries would require relocation, thus destroying a cultural landmark of the New Jersey shore. Additionally, roads, railroads, water supply facilities, electric power, and telephone and sewerage utilities would also have to be relocated. Lands acquired in this manner could be used for undeveloped parks, or other purposes that would not result in material damage from erosion. The level of development at the problem area under study would make this measure prohibitively expensive.

3.2 NO ACTION ALTERNATIVE

The no action alternative would allow beach erosion to continue, resulting in an increased risk of property destruction during storms. The base condition of this alternative entails continuation of the existing serious beach erosion problem and storm damage threat, with reliance on emergency evacuation measures, floodplain regulations as required under Federal, State and local authorities and flood insurance under Federal programs. Continued erosion would reduce recreational opportunities. This would have the secondary economic effect of reducing tourism, which would in turn lower employment levels and the flow of revenue into the area. In the absence of Federal participation, limited State or local efforts to contain erosion and storm damage might be undertaken. However, small scale efforts would not be effective in meeting with the project's needs and goals. Therefore, this alternative was eliminated from further consideration.

3.3 COMPARATIVE IMPACT ANALYSIS OF THE ALTERNATIVES

The beach nourishment alternative best meets the needs and objectives for the ocean front portion of the project, and was chosen as the basis for further environmental, engineering, design and cost estimate evaluations. The construction of two timber sheet-pile bulkheads best meets the needs and objectives for the Absecon Inlet frontage. The screening criteria used to evaluate some of the various alternatives and the results of that screening are shown on Tables 5 through 8. A detailed discussion of alternative screening can be found in the Plan Formulation section of the main report.

3.4 PREFERRED ALTERNATIVE: BEACH NOURISHMENT

Because the previously discussed alternatives would not fully accomplish the study objectives, the beach nourishment alternative is the preferred plan for the ocean front. The beach nourishment plan recommends that a selected berm width along with a selected dune height be maintained along the Absecon Island ocean frontage. Periodic re-nourishment will be necessary to maintain desired berm widths and dune heights. The preferred alternative also includes the construction of two timber sheet-pile bulkheads along the Absecon Inlet frontage.

3.5 THE SELECTED NED PLAN

Several intermediate alternatives utilizing various beach nourishment schemes were screened during Cycle 3 of the Feasibility Study. The plan selected from this screening is the NED (National Economic Development) Plan. The NED plan is the alternative with the highest net benefits for storm damage reduction over costs. The selected (NED) plan, berm and dune restoration through beach nourishment, consists of a 200 foot wide berm with a top elevation of +8.5 feet NGVD. A dune with a top elevation of +16 feet NGVD29, top width of 25 feet, and side slopes of 1V:5H will also be constructed, with the landward toe of the dune located 25 feet seaward of the seaward edge of the boardwalk. In Ventnor, Margate, and Longport the beachfill will have a 100 foot wide berm with a top elevation of +8.5 feet NGVD. Dunes will also be constructed to a top elevation of +14 feet NGVD, with a 25 foot top width, and side slopes of 1V:5H. The selected plan will be transitioned from a 200 foot berm to a 100 foot berm between Atlantic City and Ventnor for a distance of 1000 feet. The selected plan also includes the construction of two timber sheet-pile bulkheads along Absecon Inlet. Details of

Table 5
Absecon Inlet (Atlantic City)
Cycle 1 - First Level Screening Results

Alternative	Technical Feasibility	Meet Objectives?	Relative Cost	Further Consideration in Cycle 2?	Remarks
Nonstructural Alternatives	Partial	No	Varies	No	Could encourage development in coastal wetlands.
Beach Restoration	Partial	Partial	Moderate	Yes	Adverse environmental impacts can be minimized through coordination with environmental agencies. Existing shoreline slope may not be adequate to support stable berm. May increase inlet shoaling.
Bulkhead with revetment	Yes	Partial	Moderate	Yes	Bulkheads would require toe protection.
Navigation Type Breakwater	Partial	Partial	Very High	No	Reduces wave heights in navigation channel and on inlet shoreline. Costs must be offset by benefits to navigation and reduced periodic nourishment requirements.
Realignment of the Channel	No	No	High	No	Depth is already greater than the authorized channel throughout the inlet. Modifications may have adverse impact on channel stability.
Relocate Boardwalk	Yes	Partial	High	Yes	
Perched Beach (Geo-tubes)	Partial	Partial	High	No	Existing water depth is too deep to accommodate a perched beach with sufficient berm width to provide shore protection benefits.
Wave Breaking Structure	Yes	Partial	Moderate	Yes	Rough slope to absorb wave energy before impacting on bulkhead.
Lengthen Brigantine Jetty	Partial	Partial	Very High	Yes	May have adverse impacts on natural bypassing of sediment to Absecon Island.

Table 6
Absecon Island Ocean Front
Cycle 1 - First Level Screening Results

Alternative	Technical Feasibility	Meet Objectives?	Relative Cost	Further Consideration in Cycle 2?	Remarks
Nonstructural Alternatives	Partial	No	Varies	No	Could encourage development in coastal wetlands.
Beach Restoration	Yes	Partial	Moderate	Yes	Berm pushes the breaker zone and inundation profile seaward. Provides sacrificial sediment during storms.
Beach Restoration with Dune	Yes	Yes	Moderate	Yes	Provides buffer during storms and can provide aesthetic value by planting with dune grass. Dune grass can also help to stabilize the dune for storm protection.
Beach Restoration with Bulkheading	Yes	Yes	High	Yes	Bulkheads perform the same function as dune but is more costly and may require toe protection and can cause adverse affects during storms.
Beach Restoration with Groin field	Yes	Yes	High	Yes	Costs must be offset by reduced periodic nourishment requirements.
Offshore Berm	Partial	Partial	Moderate	No	Costs must be less than direct placement of material on beach.
Offshore Detached Breakwaters W/ Beachfill	Partial	Partial	Very High	No	Costs must be offset by reduced periodic nourishment requirements. Less viable in high wave energy environments.
Seawall	Yes	Partial	Very High	No	There is debate that seawalls can exacerbate erosion.
Perched Beach	Partial	Partial	High	No	Costs must be offset by reduced periodic nourishment requirements.
Submerged Reef W/ Beachfill	Partial	Yes	High	No	Costs must be offset by reduced periodic nourishment requirements.
Extend Longport Terminal Groin w/beachfill	Yes	Yes	High	Yes	Costs must be offset by reduced periodic nourishment requirements.

Table 7
Absecon Inlet (Atlantic City)
Cycle 2 - Second Level Screening Results

Alternative	Design Considerations	Environmental Considerations	Social Considerations	Preliminary Annualized Costs	Total Annualized Damages	Further Consideration in Cycle 3?	Remarks
Beach Restoration	50' Berm	Smother organisms on beach. Kill organisms in borrow area.	Provide usable beach area.	$900,000	$1,425,000	No	The existing slope would require a substantial quantity of material for stability. This project would have to be built in conjunction with the extension of the Brigantine Jetty.
Relocate Boardwalk	1,700 linear feet.		Increased accessibility.	$106,000	$96,000 (Boardwalk damages only.)	No	Costs outweigh potential benefits.
Wave Breaking Structure	1,050 linear feet.	Reduce sandy environment. Increase rocky habitat.	Less aesthetically pleasing than sandy beach.	$96,000	$1,425,000	Yes	
Bulkheading with revetment	1,050 linear feet.	Reduce sandy environment.	Uniformity of inlet bulkheading would provide better appearance than currently exists.	$89,000	$1,425,000	Yes	Bulkheads would require toe protection (rubble revetment) and can cause increased runup during storms.
Lengthen Brigantine Jetty	Extend 2000 feet to a total length of 5,749 ft at +8ft MLW.	Temporary dredging impacts such as increased turbidity and destruction of benthic habitat.	Reduced wave energy in inlet providing safe haven for boaters. Hazard to navigation.	$521,000	$1,425,000	Yes	Costs must be offset by reduced wave damages only.

Table [illegible]
Absecon Island Ocean Front
Cycle 2 - Second Level Screening Results

Alternative	Design Considerations	Environmental Considerations	Social Considerations	Preliminary Annualized Costs	Total Annualized Damages	Further Consideration in Cycle 3?	Remarks
Beach Restoration	100' Berm, +8.5 ft. NGVD.	Smother organisms. Kill organisms in borrow area. Can increase nesting and beach habitat.	Provide usable beach area.	$1,329,000	$16,025,000	Yes	Adverse environmental impacts can be minimized through coordination with environmental agencies.
Beach Restoration with Dune and Groin field	AC: Two stone groins, 1200' apart, 400' length from 10'MLW to 7' MLW at seaward end.	Same as beach restoration.	Same as beach restoration but there may be aesthetic problems with hardened structures.	$607,000 (Atlantic City only)	$6,943,000 (Atlantic City only)	Yes	Costs must be offset by reduced periodic nourishment requirements.
	Longport: Six stone groins, 100' apart, 400' length from 10'MLW to 7' MLW at seaward end.			$1,375,000 (Longport only)	$4,943,000 (Longport only)	Yes	
Beach Restoration with Bulkheading (no dune)	100' Berm, 12,700 l.f. bulkhead (Atlantic City).	Same as beach restoration.	Same as beach restoration.	$1,071,000 (Atlantic City)	$6,943,000 (Atlantic City)	No	Bulkheads perform the same function as dune but are more costly. Road ends are existing low points in elevation.
	100' berm, 1400 l.f. bulkhead at road ends (Margate, Ventnor & Longport).			$1,198,000 (Ventnor, Margate & Longport).	$9,082,000 (Ventnor, Margate & Longport).	Yes	
Beach Restoration with Dune	185' berm and dune width. Berm: +8.5 ft. NGVD. Dune: 25 ft top width, +12.5 ft. NGVD.	Same as beach restoration, in addition, enhancement of backshore environment.	Same as beach restoration but there are those who are inconvenienced by dunes.	2,118,000	$16,025,000	Yes	Provides buffer and sediment stockpile during storms and can provide aesthetic value by planting with dune grass.
Extend Longport Terminal Groin	1000' total length.	Temporary dredging impacts such as increased turbidity and destruction of benthic habitat.		$128,000	$4,943,000 (Longport only)	Yes	Costs must be offset by reduced periodic nourishment requirements. Possible effects on the Great Egg Harbor Inlet ebb shoal.

the selected plan are shown on Figures 2 and 3. The selected plan includes:

- A total sand fill quantity of approximately 6.2 million cubic yards is needed for the initial fill placement over the entire length. This quantity includes tolerance, overfill and advanced nourishment.
- 91 acres of planted dune grass and the erection of 63,675 linear feet of sand fence for entrapment of sand on the dune and delineating walkovers and vehicle access ramps.
- 170 pedestrian dune walkovers and 10 vehicle access ramps over the dunes.
- Renourishment of approximately 1,666,000 cubic yards of sand fill from the offshore borrow area every 3 years for the 50 year project life.
- Beachfill for the proposed project is available from 3 offshore borrow areas with a total area of approximately 753 acres. The proposed borrow areas are located within Absecon Inlet, offshore of Absecon Inlet, and offshore of Great Egg Harbor Inlet. Details of the borrow sites and the borrow material are provided in the Borrow Area Selection section of the Main Report.
- To properly assess the functioning of the proposed plan, monitoring of the placed beachfill, borrow area, shoreline, wave and littoral environment is included with the plan. Environmental monitoring is being addressed through coordination with other interested agencies, and will be finalized prior to initial construction.

3.5.1 OFFSHORE BORROW AREA INVESTIGATION

Through the use of maps and charts which show offshore bathymetry, plans and specifications records for previous beachfill jobs, literature which included vibracore logs from previous investigations, and coordinates for overboard disposal areas of dredged material, the three proposed borrow areas in this report were identified. Based upon the search of existing literature, the three areas identified as potential borrow sites include all of the likely sites where large deposits of sand can be found. The Absecon Inlet borrow area was initially identified since portions of this area had been mined previously for beachfill. The Great Egg Harbor Inlet borrow area was initially identified due to the fact that a portion of the ebb shoal was already in use supplying high-quality beachfill material for Ocean City, N.J. The offshore borrow area was initially identified as a bathymetric feature (a shoal) which would probably contain suitable beachfill material. The vibracores were then conducted for these areas to obtain sediment samples for testing and suitability analysis. The vibracore samples verified the suitability of sand within these three borrow areas for use as beachfill material for Absecon Island. All three borrow areas were then designated as possible borrow sites for the Absecon Island project. Once these areas were identified as sources of suitable beachfill material, environmental and cultural investigations were completed. The environmental field investigations consisted of benthic sampling and tows for surf clams. The results of these investigations indicated that the use of Absecon Inlet borrow area would reduce the impacts to benthic and surf clam resources, as the offshore area and Great Egg Harbor Inlet area have much higher densities of surf clams. To further lessen any impacts to surf clams, the size of the Absecon Inlet borrow area was curtailed and it was decided that the initial quantity of sand and the first few nourishment cycles would utilize this borrow site.

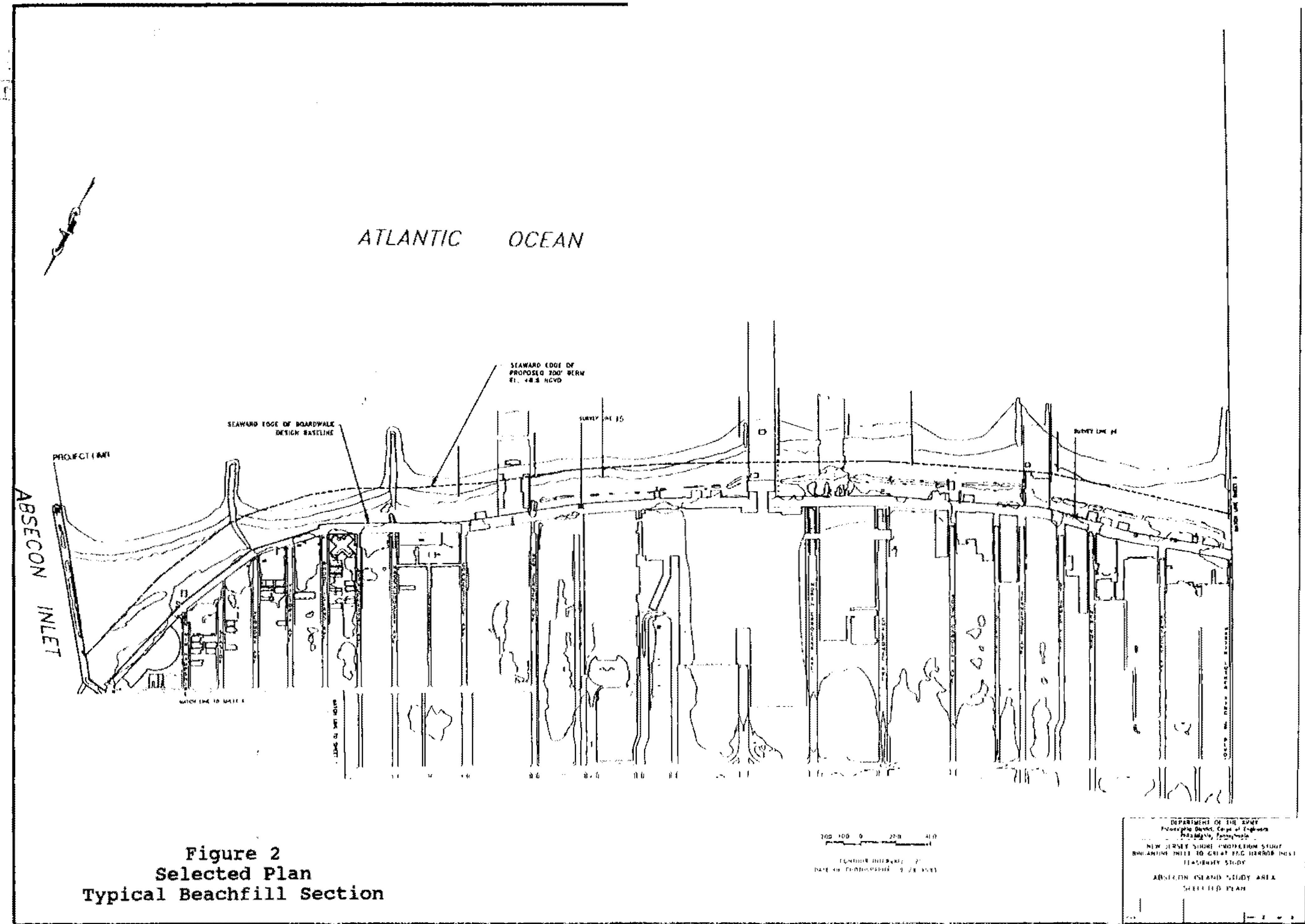


Figure 2
Selected Plan
Typical Beachfill Section

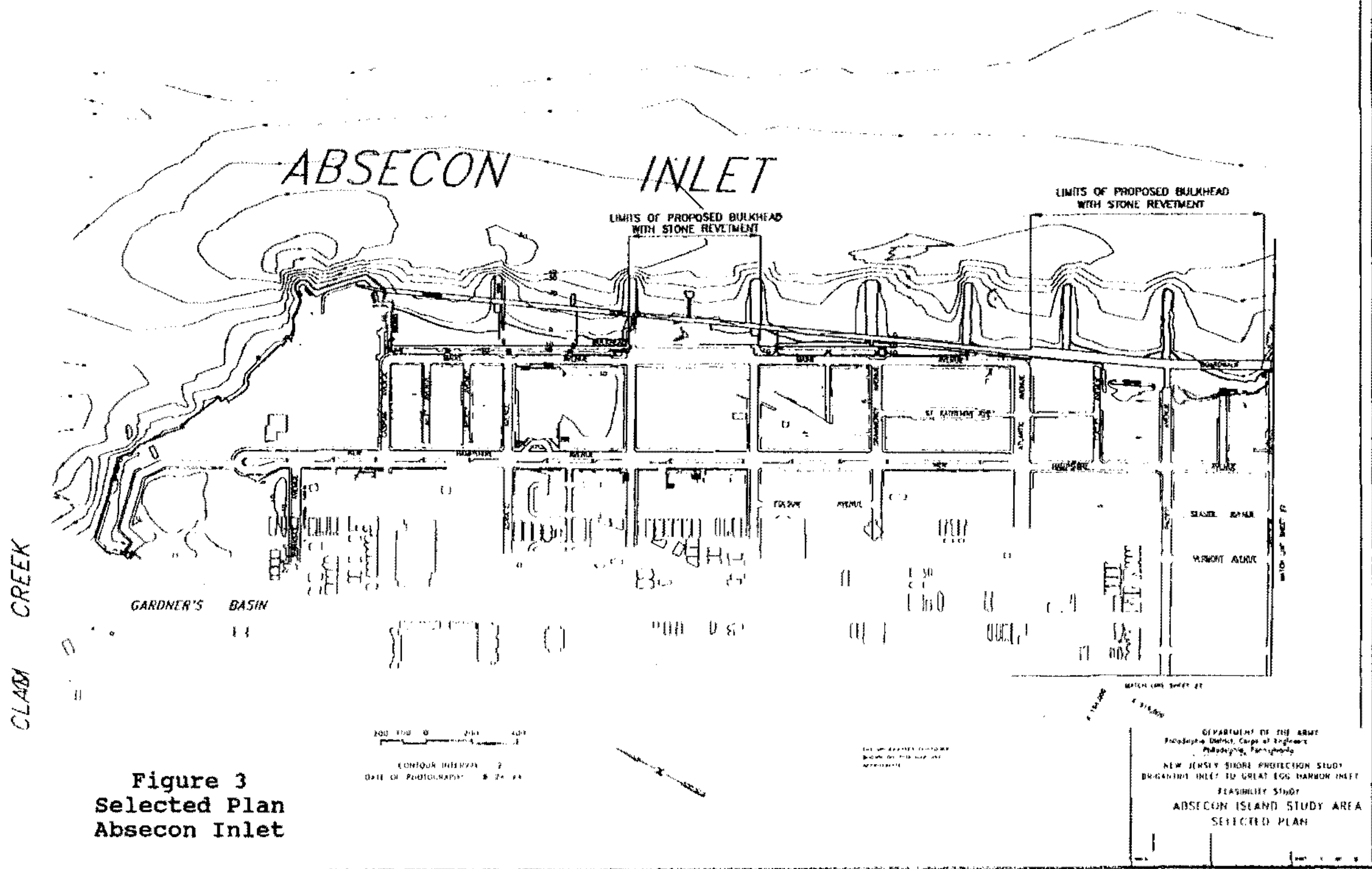


Figure 3
Selected Plan
Absecon Inlet

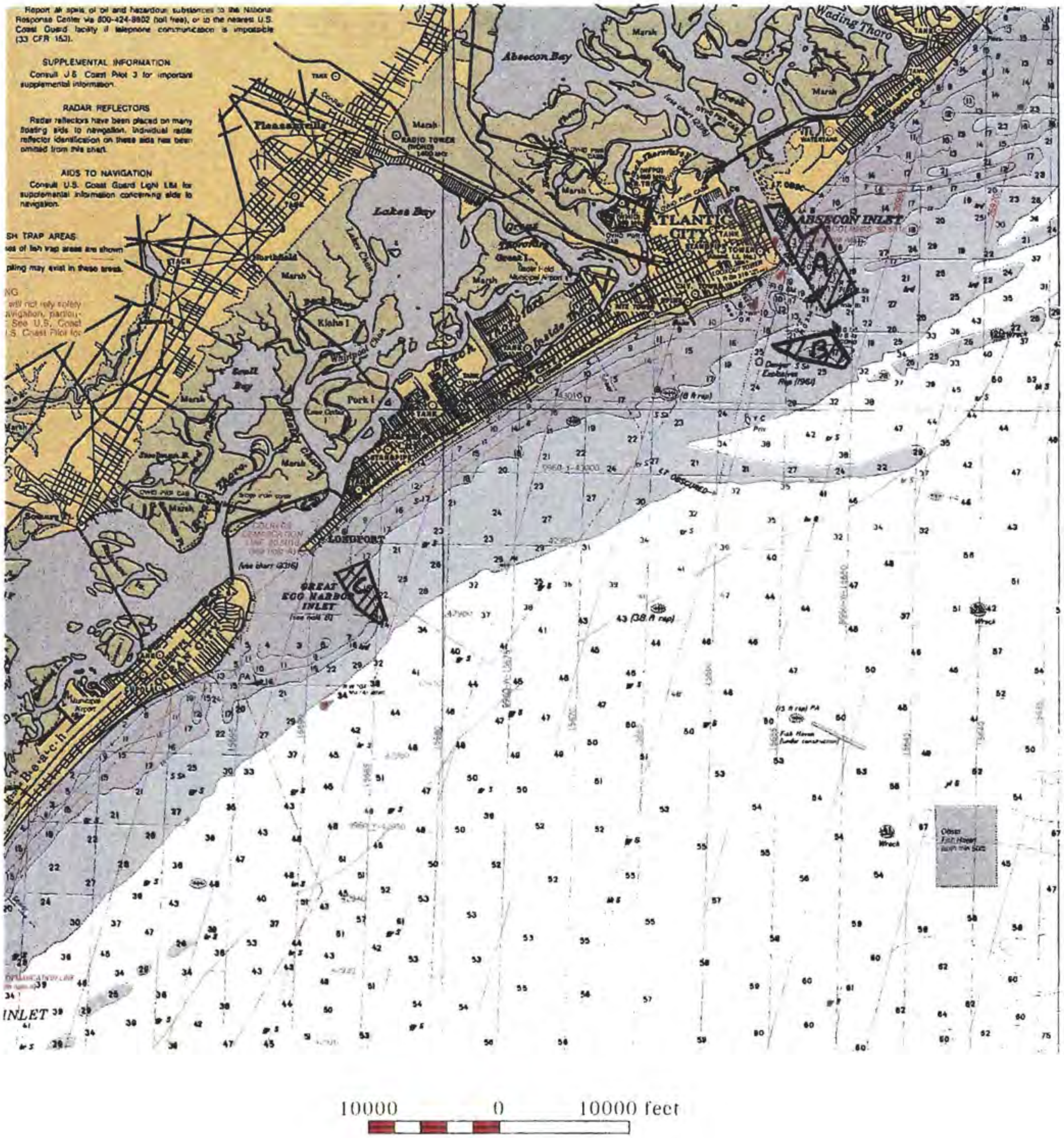
The Reconnaissance Study report identified several possible borrow areas for Absecon Island. In order to specifically identify sources of sand for the Absecon Island feasibility study, a series of 15 vibrocores were collected. The vibrocores were collected by Alpine Ocean Seismic Survey, Inc. in the Atlantic Ocean off of the coast of New Jersey. The samples were collected between 12 October and 27 October 1993. The desired depth of penetration for the vibrocores was 20 feet. Sieve analysis of the sediment retrieved in the vibrocores was conducted by the Army Corps of Engineers South Atlantic Division Laboratory (SAD Lab).

Vibrocore borings for borrow area identification were accomplished in three specific locations. The first location was Absecon Inlet, the second location was offshore of Atlantic City, and the third location was Great Egg Harbor Inlet (Figure 4). The results of the vibrocore investigation and analysis indicate that all three of these areas meet the criteria for potential borrow areas for Absecon Island. The first potential borrow area is the northern portion of Absecon Inlet. The second potential borrow area lies approximately 1 to 1-1/4 miles offshore of Atlantic City. The third area is located northeast of Great Egg Harbor Inlet. All three areas contains large quantities of fine sand as identified by the sieve analysis conducted by the SAD Lab. Ideally, borrow material should be the same size, or slightly coarser than the native material on the beach to be nourished. If the borrow material has a significantly smaller grain size, the profile will be out of equilibrium with the local wave and current environment, and will therefore be quickly eroded either offshore or alongshore. This analysis compares the native sediment characteristics to the borrow material characteristics. Overfill factors and renourishment factors were calculated for each potential borrow area. The overfill factor estimates the volume of fill material needed to produce one cubic yard of stable beach material after equilibrium (when the beach and native materials are compatible) is reached. Consequently, overfill factors are greater or equal to one. For example, an overfill ratio of 1.2 would indicate that 1.2 cubic yards of borrow material would be required to produce 1.0 cubic yards of stable beach material. This technique assumes that both the native and composite borrow material distributions are nearly log-normal. The renourishment factor is a measure of the stability of the placed borrow material relative to the native beach sand. Desirable values of the renourishment factor are those less than or equal to one. For example, a renourishment factor of 0.33 would mean that renourishment using the borrow material would be required one third as often as renourishment using the same type of material that is currently on the beach.

Based on the information gathered from the vibrocores, it appears that the proposed borrow area in Absecon Inlet would provide compatible sand with the least amount of overfill and the longest renourishment cycle. The Absecon Inlet offshore borrow area and the Great Egg Harbor Inlet borrow area would require larger amounts of overfill, and would have more frequent renourishment cycles than the Absecon Inlet borrow area.

Figure 4

Absecon Island Borrow Areas



Absecon Island Borrow Areas

3.6 SUMMARY OF ENVIRONMENTAL EFFECTS OF PLAN

The primary adverse impact of the beach nourishment alternative is the temporary disturbance and destruction of existing benthic resources from dredging operations at the borrow area, and fill placement along the shorefront. Dredging in the borrow area will result in a temporary destruction of the benthic commmunity, however, rapid recolonization is expected to occur within one year from dredging. Minor shifts in benthic community composition may occur following recolonization. Beachfill operations along Absecon Island will result in temporary degradation of the existing beach habitat during initial construction and periodic nourishments. Existing benthic organisms on the beach would become buried as a result of beachfilling operations. Due to the presence of species adapted to high energy and dynamic conditions, recolonization of the beach area is expected to be rapid. The portion of benthic habitat covered by any seaward extension of the beach would represent a long-term loss, however, this would be offset by the creation of similar habitat. The partial burial of groins in the project area would represent a long-term loss of rocky inter-tidal habitat occupied by aquatic invertebrates that attract birds and fish. Fish and avian utilization of the immediate shoreline area for feeding would be temporarily disrupted, however, they are expected to return immediately after the disturbance. Dredging and the hydraulic placement of beachfill material will result in temporary higher turbidity levels at the borrow site and waters along the shoreline during construction.

The construction of the timber sheet-pile bulkheads and placement of a quarrystone revetment will also result in temporary higher turbidity levels and the disturbance of the benthic community within the inlet. This aspect of the proposed plan will result in the loss of sandy bottom habitat and the destruction of the benthic community within the area to be covered by the bulkheads and associated revetment. Once construction is completed, it is expected that the newly created rocky inter-tidal habitat will be colonized with a variety of marine organisms.

4.0 AFFECTED ENVIRONMENT

4.1 THE PROJECT SITE

Brigantine and Absecon Islands are separated from the mainland by 3 to 5 miles of shallow bays which include small uninhabited islands, tidal marshes, creeks and lagoons. The ground elevation of the islands is generally no more than 10 feet above mean sea level. Absecon Island is bounded by Absecon Inlet to the north and Great Egg Harbor Inlet to the south (Figure 5). The island contains the four communities of Atlantic City, Ventnor, Margate, and Longport. It is the most densely developed of the barrier beach islands along the New Jersey coast. Both Brigantine and Absecon Islands front the Atlantic Ocean on their eastern boundaries, and have extensive coastal and estuarine wetlands on their western boundaries.

Absecon Inlet lies between Brigantine Island and Absecon Island, and provides a navigable connection between the Atlantic Ocean and the harbor of Atlantic City and the New Jersey Intracoastal Waterway (Figure 5). The inlet is extensively used by recreational and deep draft commercial craft based behind Atlantic City.

Absecon Island, a barrier island which has been heavily developed as a residential and recreational area, is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. A large segment of the lands to the northwest of the barrier island are classified as a backbay/coastal salt marsh system. Brigantine Island is much less developed, and is primarily classified as a marine intertidal beach/bar behind which are palustrine emergent, estuarine intertidal and palustrine scrub-shrub wetlands. Common species of the beach and dune area on the barrier island system include beach grass, sea-rocket, seaside goldenrod, poison ivy, groundsel-tree, and marsh elder.

The backbays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. The low marsh zone is typically dominated by saltmarsh cordgrass. Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks and other organisms. Dominant species include sea lettuce and eelgrass. The high marsh zone, which is slightly lower in elevation than the transition zone is dominated by saltmeadow cordgrass and salt grass. This zone is typically flooded by spring high-tide. Plants typical of the transition zone include both upland and marsh species including marsh elder, groundsel-tree, bayberry, saltgrass, sea-blite, glasswort, poison ivy, and common reed.

4.2 CLIMATE

4.2.1 Temperature and Precipitation

The Delaware Bay and Atlantic Ocean coastal region experiences a moderate climate associated with the low elevations of the Coastal Plain and the presence of the large water bodies. A moderate winter season results from winds which are heated by warmer water temperatures of the ocean and bays and blown inland. Summer temperatures are in turn moderated by locally generated

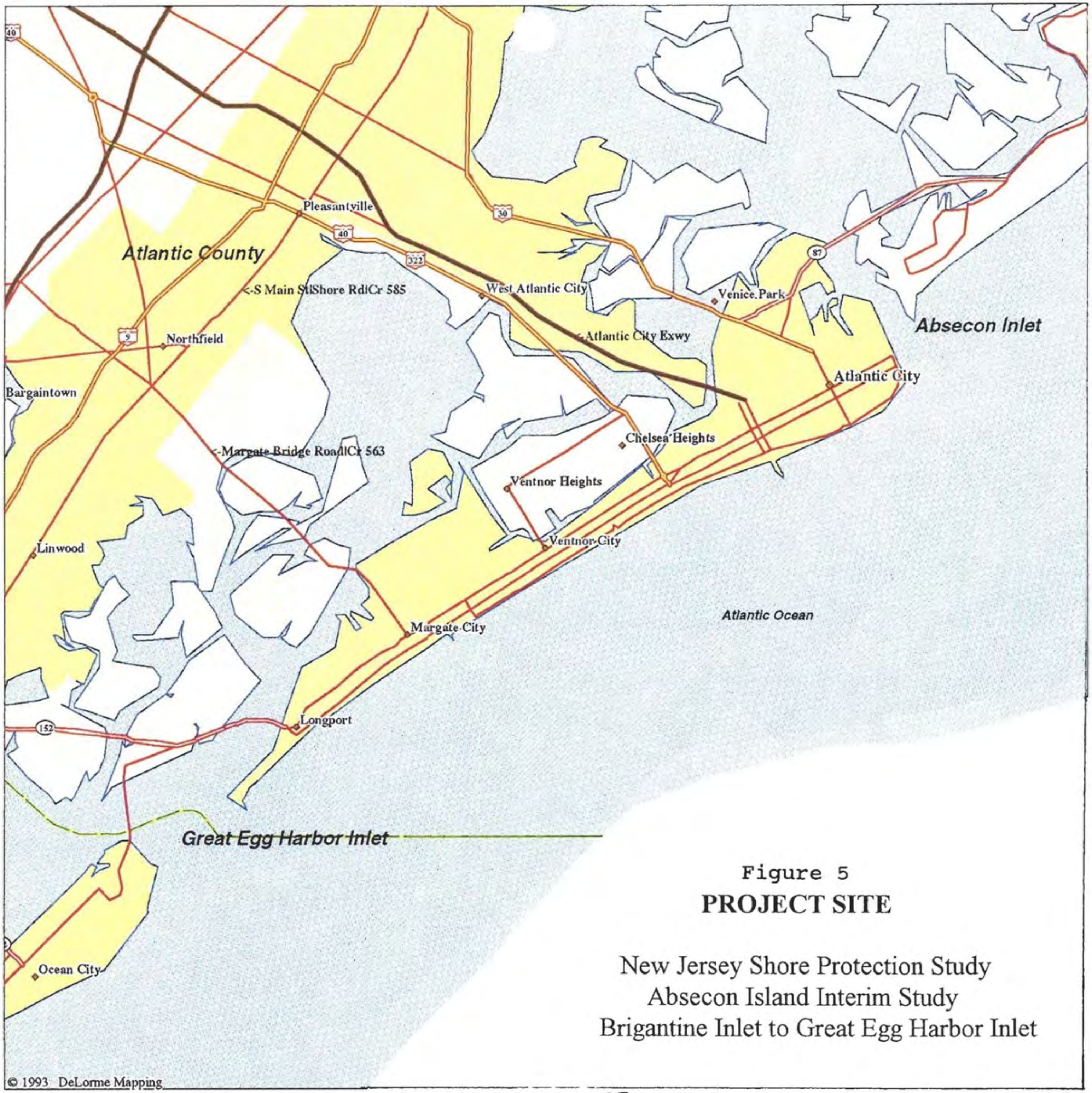


Figure 5
PROJECT SITE

New Jersey Shore Protection Study
Absecon Island Interim Study
Brigantine Inlet to Great Egg Harbor Inlet

winds or sea breezes. The following information is quoted from the 1992 Annual Summary of Local Climatological Data, and is considered to be fully representative of conditions along Absecon Island.

"Land and sea breezes, local circulations resulting from the differential heating and cooling of the land and sea, often prevail. These winds occur when moderate or intense storms are not present in the area, thus enabling the local circulation to overcome the general wind pattern. During the warm season sea breezes in the late morning and early afternoon hours prevent excessive heating. On occasions, sea breezes have lowered the temperature as much as 15 to 20 degrees within a half hour. However, the major effect of the sea breeze at the airport is preventing the temperature from rising above the 80's. Because the change in ocean temperature lags behind the air temperature from season to season, the weather tends to remain comparatively mild late into the fall, but on the other hand, warming is retarded in the spring. Normal ocean temperatures range from an average near 37 degrees Fahrenheit in January to near 72 degrees in August."

"Precipitation is moderate and well distributed throughout the year, with June the driest month and August the wettest. Tropical storms or hurricanes occasionally bring excessive rainfall to the area. The bulk of winter precipitation results from storms which move northeastward along, or in close proximity to, the east coast of the United States. Snowfall is considerably less than elsewhere at the same latitude and does not remain long on the ground. Precipitation, often beginning as snow, will frequently become mixed with or change to rain while continuing as snow over more interior sections. In addition, ice storms and resultant glaze are relatively infrequent."

4.2.2 <u>Wind</u>

As referenced in the 1984 Annual Summary from the State Marina site, the prevailing winds are from the south and of moderate velocity (14 to 28 miles per hour), and winds from the northeast have the greatest annual velocity (between 19 and 20 miles per hour). The wind data from this period also show that winds in excess of 28 miles per hour occur from the northeast more than twice as frequently as from any other direction.

The maximum five-minute average velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 82 miles per hour from the north. This storm also caused the largest recorded storm surge along the Atlantic coast of New Jersey. The fastest mile windspeed recorded at the Atlantic City Marina site over the 1960 to 1984 period was recorded during Hurricane Doria in August 1971. The fastest mile wind speed was 63 miles per hour from the southeast. The wind records generally reflect the fact that the most extreme, but infrequent, winds accompany hurricanes during the August to October period. Less extreme but more frequent high winds occur during the November to March period accompanying northeasters.

4.2.3 Storms

Storms of two basic types present a significant threat to New Jersey's coastal zone. Hurricanes are the most severe storms affecting the Atlantic Coast. Extratropical storms from easterly quadrants, particularly the northeast, also cause extensive damage to beaches and structures along the coast.

Tropical storms and hurricanes, spawned over the warm low latitude waters of the Atlantic Ocean, are probably the best known and most feared storms. Hurricanes, characterized by winds of seventy-five miles per hour or greater and heavy rain, plague the Gulf and Atlantic seaboards in the late summer and autumn. Historically, the Hurricane of 1944 and Hurricane Gloria are ranked first and fifth, respectively, in terms of maximum stage at the Atlantic City gage.

Extratropical storms, often called "northeasters", present a particular problem to the Atlantic seaboard. Such storms may develop as strong, low pressure areas over land and move slowly offshore. The winds, though not of hurricane force, blow onshore from a northeasterly direction for sustained periods of time and over very long fetches. The damage by these storms may ultimately exceed the destruction from a hurricane. The March 1962 Northeaster ranks second only to the 1944 hurricane in terms of maximum stage. The northeasters which occurred in November 1950 and December 1992 rank third and fourth for the Atlantic City gage.

The intensity and thus the damage-producing potential of coastal storms are related to certain meteorological factors such as winds, storm track, and amount and duration of precipitation. However, the major causes of coastal damage tend to be related to storm surge, storm duration, and wave action. Storm surge and wave setup are discussed in the storm erosion and inundation analysis in the without project conditions section of the Main Report.

4.3 GEOLOGY, SOILS, AND TOPOGRAPHY

4.3.1 Geology

The Atlantic coastal plain consists of sedimentary formations overlying a crystalline rock mass known as the "basement". From well drilling logs it is known that the basement slopes at about 75 feet per mile from the Fall Line to a depth of more than 6,000 feet near the coast. Geophysical investigations have corroborated these findings and have permitted determination of the profile seaward to the continental slope. A short distance offshore, the basement surface drops abruptly but rises again gradually as the continental slope is approached. Overlying the basement are semi-consolidated beds of lower Cretaceous sediments. These beds vary greatly in thickness, increasing seaward to a maximum thickness of 13,300 feet then decreasing to 8,900 feet near the edge of the continental shelf. On top of the semi-consolidated material lie unconsolidated sediments of Upper Cretaceous and Tertiary formations. These materials, in relatively thin beds on the land portion of the coastal plain, increase in thickness to a maximum of 4,800 feet near the edge of the continental shelf.

4.3.2 Soils and Topography

About 85 percent of the shorefront of New Jersey consists of a chain of narrow barrier beaches with elevations generally less than 20 feet above sea level. These beaches, each of which is approximately 7 miles in length, are separated by ten inlets. The remaining shorefront from Long Branch to Bay Head and that at Cape May Point Point, is mainland of much earlier origin than the barrier islands.

The entire portion of the coastal plain draining to the study area is a sedimentary feature that developed under essentially the same set of conditions for a considerable period of geologic time. The area is capped with almost entirely unconsolidated sediments of Tertiary or more recent deposition. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May formation, consisting largely of sand and gravel, was deposited during the last interglacial stage when sea level stood 30 to 40 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. These deposits now stand as terraces along portions of the coast and form the mainland bluff at Cape May. The barrier beaches being of relatively recent origin are composed of the same material as the offshore bottom.

4.4 COASTAL HYDRAULICS

4.4.1 Tides

The tides affecting the study area are classified as semi-diurnal with two nearly equal high tides and two nearly equal low tides per day. The average tidal period is actully 12 hours and

25 minutes, such that two full tidal periods require 24 hours and 50 minutes. Thus, tide height extremes (highs and lows) appear to occur almost one hour (average is 50 minutes) later each day. The mean tide range for the Atlantic Ocean shoreline is reported as 4.1 feet in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 5.0 feet. Absecon Channel and the back bay areas adjacent to the study area show only a small attenuation of the tide range relative to the ocean shoreline.

The NOS (National Ocean Service) tide gage nearest to the study area shoreline is located at the Trump Taj Mahal oceanfront pier in Atlantic City. Historically, a gage has been located on Absecon Island since July 1911. In July 1985, the gage was moved from its location at the Atlantic City Steel Pier, two miles south to a municipal fishing pier in Ventnor. In January 1992, the gage was moved from Ventnor to its present location at the Trump Taj Mahal Pier.

As part of the data collection efforts by the Philadelphia District, tidal data is being collected at a gage located inside of Absecon Inlet, adjacent to the highway bridge carrying Brigantine Boulevard over the Inlet. This gage collected data from November 1993 through October 1994, corresponding to the deployment period of the offshore wave gage. A summary of the tidal data collected is provided in the without project conditions section of the Main report.

4.4.2 Waves

The most recent analysis of general wave statistics for the study area shoreline is presented in a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, et al., 1993. The revised WIS data is also available digitally through the Coastal Engineering Data Retrieval System (CEDRS) developed by the U.S. Army Engineer Coastal Engineering Research Center. WIS Report 30 and information in CEDRS provides revised wave data for 108 locations along the U. S. Atlantic coast, and supersedes WIS Report 2 (Corson, et al. 1981), WIS Report 6 (Corson, et al. 1982) and WIS Report 9 (Jensen 1983). The wave information for each location is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Wave heights are universally higher for the revised hindcast than for the original hindcast, since the values more closely correspond to maximum measured (buoy) values.

Hindcast results are available as time series every 3-hr for the 20-yr period or as tabular summaries. WIS Report 30 contains tables presenting the distribution of spectral wave height, peak period and peak mean direction by month for the 20-yr period; the number of occurrences by 1-m height and 2-sec period categories for eight different direction bands and a final table for all directions; the distribution of wind in 2.5-m/sec and 45-deg speed and direction categories on a monthly basis; and finally summary tables of mean and maximum wave heights by month for each of the 20 years hindcast. These tables also include the peak period and peak mean wave direction associated with the maximum wave height occurrence.

The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast, and have been used to gain a basic understanding of the wind and wave climate at Absecon Island. The wave statistics pertinent to the Absecon Island study are those derived for Station 68 of WIS Report 30. The location of Station 68 is Latitude 39.25 N, Longitude 74.25 W, in a water depth of approximately 60 ft. Monthly mean wave heights at Station 68 for the entire 20-yr hindcast range from 2.4 ft in August to 4.4 ft in December. The maximum wave height (H_{mo}) at Station 68 for the 20-yr period is reported as 22.6 ft, with an associated peak period of 14 sec and a peak direction of 86 deg on 7 March 1962. The maximum wind speed for Station 68 for the 20-yr hindcast is reported as 89 ft/sec at 20 deg on 7 March 1962.

The actual wave spectrum experienced at any particular time along the project shoreline may show considerable local variation. This variability is largely due to the interaction of incident waves with: tidal currents at Absecon and Great Egg Inlets, ebb shoal morphology at the two inlets, local shoreline alignment, nearshore bathymetry, and presence of shoreline stabilization structures. Therefore, the hindcast wave statistics should be viewed as a very general representation of the wave climate of the study area offshore. Inshore of the 60 ft depth, the effects enumerated above will modify the incident waves such that significant alongshore differences may exist with respect to breaking wave height and angle relative to the shoreline. Computer programs which transform offshore waves over varying bathymetry must be used to further investigate wave conditions closer to the shoreline.

Prototype wave data collection in the vicinity of Absecon Island was collected for the Philadelphia District between November 1993 October 1994. A directional wave gage of the "PUV" type collected data at a depth of approximately 35 ft offshore of the Trump Taj Mahal Pier. A nearshore directional wave gage collected data in approximately 10 ft of water near the entrance to Absecon Inlet. Wave data were analyzed and utilized in the with-project shoreline and inlet process modeling efforts. Prototype wave data summaries are presented in the Main Report.

4.4.3 Currents

The Philadelphia District collected tidal current data offshore just south of the Absecon Inlet mouth from November 1993 to January 1995. This data includes a large set of current speed and direction measurements at a single location from a bottom mounted self-recording current meter. This data is more relevant to ocean facing shoreline parallel tidal currents than inlet currents because of the location of the current meters. The data was taken at three hour intervals. Typical plots of tidal current data are provided in Appendix A of the main report.

In addition, tidal currents and flow estimates for Absecon and Brigantine Inlets are available from a study conducted in September 1994 by CERC for the Philadelphia District. Acoustic Doppler Current Profiler (ADCP) measurements were taken at Absecon Inlet to provide estimates of depth averaged currents at specified crossections and flow volumes as a function of time over most of a tidal cycle. Typical plots of the current data collected are provided in Appendix A of the main report.

The data collected across the inlet throat indicate that during flood tide the higher water velocities are located on the south side of the channel. During ebb tide, the currents are generally uniform across the channel. During peak ebb, slightly higher velocities are concentrated on the north side of the inlet. At maximum flood, depth-averaged water velocities of over 5.6 ft/sec were measured. In general, ebb velocities were lower than the flood velocities. Typically, maximum water velocities on the ebb tide were on the order of 4.9 ft/sec.

Maximum tidal current velocities through Absecon Inlet have been previously documented as 3.1 ft/sec (U.S. Army Corps of Engineers, 1943) with currents flowing past the adjacent beaches reaching maximum velocities of less than 1.0 ft/sec.

4.5 WATER QUALITY OF NEW JERSEY ATLANTIC COASTAL WATERS

4.5.1 Temperature and Salinity

Mixing occurs in nearshore waters due to the turbulence created from wave energy contacting shallower depths. This mixing becomes less prominent in greater depths where stratification can develop during warm periods. Water temperatures generally fluctuate between seasonal changes. The average temperature range is from 3.7°C (January) to 21.4°C (October). The most pronounced temperature differences are found in the winter and summer months. Warming of coastal waters first becomes apparent near the coast in early spring, and by the end of April thermal stratification may develop. Under conditions of high solar radiation and light winds, the water column becomes more strongly stratified during the months of July to September. The mixed layer may extend to a depth of only 12 to 13 feet. As warming continues, however, the thermocline may be depressed so that the upper layer of warm, mixed water extends to a depth of approximately 40 feet. Salinity concentration is chiefly affected by freshwater dilution. Salinity cycles result from the cyclic flow of streams and intrusions of continental slope water from far offshore onto the shelf. Continental shelf waters are the least affected by freshwater dilution, and have salinity concentrations varying between 30 parts per thousand (ppt) and 35 ppt. Coastal waters are more impacted by freshwater dilution, and may have salinities as low as 27 ppt. Salinity is generally at its maximum at the end of winter. The voluminous discharge of fresh water from the land in spring reduces salinity to its minimum by early summer. Surface salinity increases in autumn when intrusions from offshore more than counterbalance the inflow of river water, and when horizontal mixing becomes more active as horizontal stability is reduced. Recent near-bottom water quality parameters were measured, in October 1994, within the proposed sand borrow sites during benthic sampling. The near-bottom temperature ranged from 15.1 - 15.9°C, and the dissolved oxygen and salinities ranged from 6.0 - 7.7 mg/L and 31.4 - 31.7 ppt, respectively (Battelle Ocean Sciences, 1995).

4.5.2 Water Quality Parameters

Through the State of New Jersey's Cooperative Coastal Monitoring Program (CCMP), coastal and backbay water quality is monitored by the Atlantic County Health Department and Atlantic City Health Department. Ocean and bay stations are monitored once a week from May to September for fecal coliform. According to the New Jersey Department of Environmental Protection (NJDEP) Surface Water Quality Standards (SWQS) NJAC 7:9 4.1, fecal coliform levels for ocean areas are not to exceed 50 per 100 milliliters of sample (SWQS 50). For the bay areas, fecal coliform concentrations are not to exceed 200 per 100 millimeters (SWQS 200). Eight sites in Atlantic County are also analyzed for enterococci bacteria in an effort to quantify other bacterial indicators of contamination. The following data is derived from the Coastal Cooperative Monitoring Program Annual Reports, published by the Division of Water Resources, NJDEP.

In 1989, 28 ocean and 15 bay stations were monitored as part of this program. Of the 570 ocean samples collected, 93 exceeded the SWQS 50 and 21 exceeded the primary contact criterion of 200 per 100 milliliters of sample (PCC 200). Thirty-six of the 272 bay samples exceeded the SWQS and PCC 200. Excessive, continuous rainfall contributed to bacterial loading from stormwater pipes into the surf zone. Of the 466 samples collected from 26 ocean stations in 1988, 44 of the samples exceeded the SWQS 50 and 4 exceeded the PCC 200. In addition, 218 bay stations were monitored and 27 samples exceeded SWQS and PCC 200. In 1987, 587 ocean samples were collected and 83 samples exceeded SWQS 50 and 36 exceeded PCC 200. The ocean stations with geometric means exceeding the SWQS were located in Atlantic City. Thirty-seven of the 183 bay samples collected from 10 bay stations exceeded SWQS and PCC 200.

As a result of this monitoring program, recreational beaches may be closed if two consecutive fecal coliform concentrations are above the PCC. From August 17 to 22, 1987, the entire Atlantic City beach was closed due to contaminated water flow from stormwater pipes discharging to the ocean. Several possible sources of contamination into the storm sewer system were identified. Beach closings in 1988 were abnormally high due to a malfunction at the Asbury Park wastewater treatment facility. This incident occurred immediately prior to its conversion from a primary level sewage treatment to secondary level.

According to the CCMP's 1993 Annual Report, bacteria-related closings of ocean beaches from 1988 through 1991 decreased but then increased again in 1992 and 1993. These closings were attributed to stormwater discharges, rather than discharges from wastewater treatment facilities. In 1991, isolated beach closures occurred after rains. Stormwater can be contaminated during overland flow during rainfalls, and during underground transport before being discharged into a waterway. In contrast to the 1991 numbers, 27 beach and 84 bay closings occurred in 1992. Twenty-two of the beach closings occurred immediately following five days of rain in August. Concentrations of fecal coliforms increase after rain due to the flushing effect of stormwater runoff. Excessive fecal coliform concentrations or suspected sewage pollution accounted for 26 of the 27 ocean beach closings and all of the bay beach closings in 1992. In comparison, 10 ocean beach closings in 1991 were attributable to those causes. In 1993, some of the 34 beach and 54 bay closings were attributed to sewage discharges related to occurrences of stormwater discharge.

No closings due to floatable debris washups have occurred since 1990. It is believed that the floatables removal activities of the U.S. Army Corps of Engineers, and the DEP's Operation Clean Shores are in part responsible for the decrease in floatables in the harbors and nearshore coastal waters. Table 9 compares the number of beach and bay closings from 1988 through 1993.

The results of the Coastal Cooperative Monitoring Program have indicated that direct stormwater discharge to the ocean, and indirect discharge via tidal flow from the bay inlets, can be correlated with increased concentrations of fecal coliform at the program stations. Compounding the stormwater effect on backbay fecal coliform levels are bacterial loadings from illegal discharge of marine sanitation devices on boats, the pressure of large animal populations, and the resuspension of sediments by boat traffic and dredging.

Another indication of the water quality in an area can be derived from the State of New Jersey's annual Shellfish Growing Water Classification Charts. Waters are classified as approved, special restricted, seasonal or prohibited for the harvesting of shellfish as seen in Figure 6. In general the poorest water quality areas are located in the nearshore environment of the heavily populated Atlantic City, and backbay harbors and thorofares where circulation and flow is restricted on either one or both ends. The near shore waters from Absecon Inlet to Ventnor City are prohibited (condemned) for the harvest of oysters, clams and mussels. The waters of Absecon Inlet are seasonal/special restricted. Seasonal areas are condemned for the harvest of shellfish except during certain times, while special restricted areas are condemned for the harvest of shellfish except for further processing under special permit. The backbays immediately adjacent to Brigantine Island are classified as seasonal; however, the waters that extend further back towards Reeds Bay are approved for shellfish harvesting. The waters within one mile of Brigantine's beaches are classified as a Surf Clam Conservation Zone. The backbays extending from Absecon Inlet to Great Egg Harbor Inlet are for the most part seasonal or special restricted. A few isolated thorofares and harbors are classified as prohibited.

4.6 TERRESTRIAL ECOLOGY OF AFFECTED AREA

4.6.1 Dunes

The study area encompasses both the barrier island and back bay/coastal salt marsh systems. Absecon Island, a barrier island which has been heavily developed as a residential and recreational area, is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. A large segment of the lands to the northwest of the barrier island are classified as a back bay/coastal salt marsh system.

Although typical beach dunes and the habitats associated with them are almost non-existent within the project area, a few elements of beach dune flora and fauna are still present. The only area currently having a dune system within the project area is in Atlantic City where small man-made dunes exist in some sections. The following discussion on beach dunes mainly pertains to surrounding areas outside of the Absecon Island project impact area, however, some of the dune flora and fauna discussed may still be present in limited pockets.

TABLE 9

Beach Closings

	Reasons	1993	1992	1991	1990	1989	1988
Ocean Closings	Bacteria	34	27	10	22	35	784
	Floatables	0	0	0	10	9	19
	Total	34	27	10	32	44	803
Bay Closings	Bacteria	54	84	97	202	232	52

Source: New Jersey Department of Environmental Protection, Cooperative Coastal Monitoring Program, The Annual Report for 1993

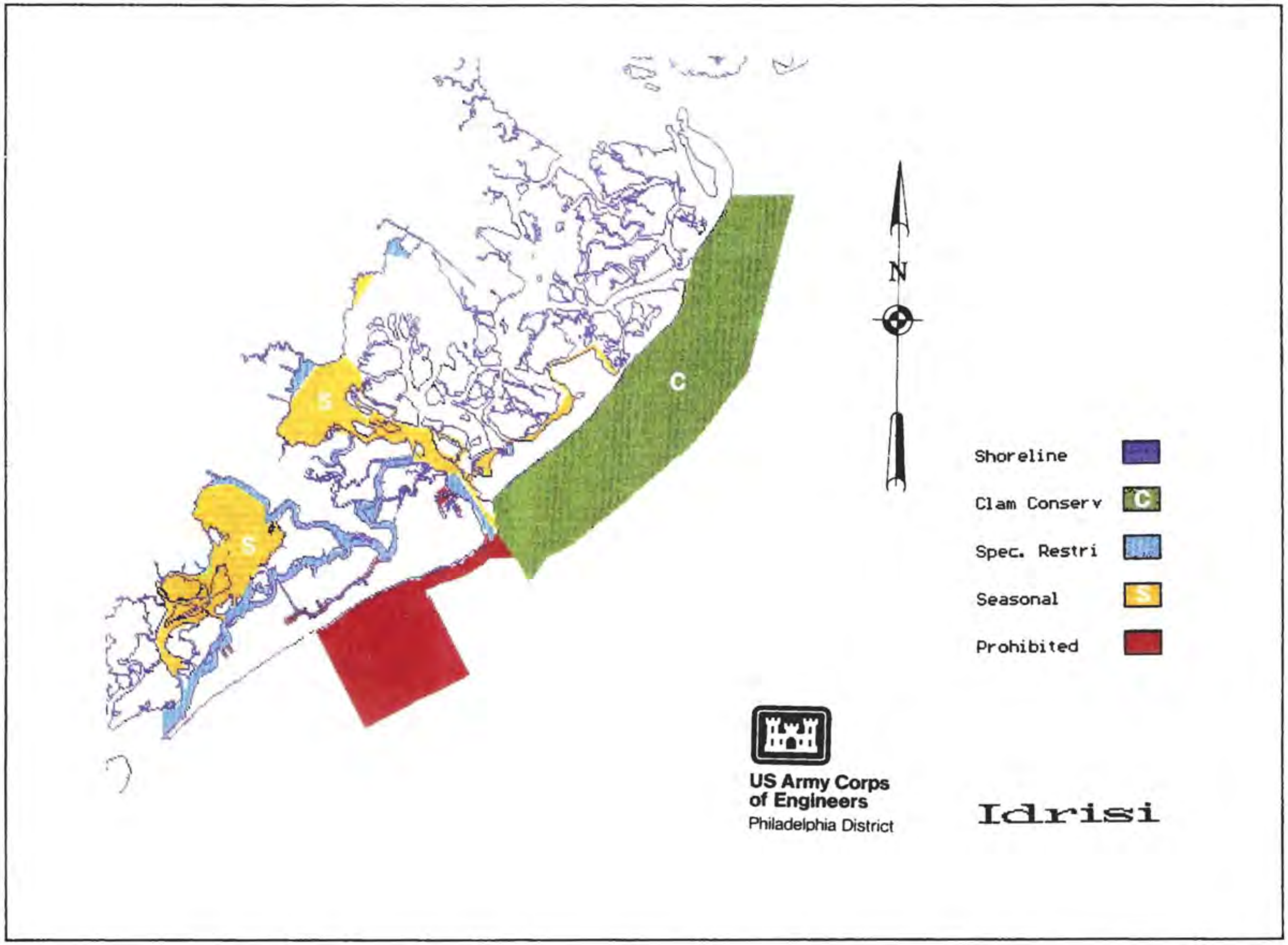


FIGURE 6 Shellfish Growing Water Classification Chart. Digitized from NJDEPE, 1992.

In typical undisturbed beach profiles along the Atlantic Coast of New Jersey, the primary dune is the first dune landward from the beach. The flora of the primary dune are adapted to the harsh conditions present such as low fertility, heat, and high energy from the ocean and wind. The dominant plant on these dunes is American beachgrass (Ammophila breviligulata), which is tolerant to salt spray, shifting sands and temperature extremes. American beachgrass is a rapid colonizer that can spread by horizontal rhizomes, and also has fibrous roots that can descend to depths of 3 feet to reach moisture. Beachgrass is instrumental in the development of dune stability, which opens up the dune to further colonization with more species like seaside goldenrod (Solidago sempervirens), sea-rocket (Cakile edentula) and beach cocklebur (Xanthium echinatum).

The secondary dunes lie landward of the primary dunes, and tend to be more stable resulting from the protection provided by the primary dunes. The increased stability also allows an increase in plant species diversity. Some of the plant species in this zone include: beach heather (Hudsonia tomentosa), coastal panic grass (Panicum amarum), saltmeadow hay (Spartina patens), broom sedge (Andropogon virginicus), beach plum (Prunus maritima), seabeach evening primrose (Oenothera humifusa), sand spur (Cenchrus tribuloides), seaside spurge (Ephorbia polygonifolia), joint-weed (Polygonella articulata), slender-leaved goldenrod (Solidago tenuifolia), and prickly pear (Opuntia humifusa).

Along undeveloped portions of the New Jersey Atlantic Coastline, the primary and secondary dunes grade into a zone of shrubby vegetation. These zones are typically located on the headlands or on the barrier flats of the barrier beaches. This zone is called the scrub-thicket zone where sand movement is more diminished. Many of the flora are dwarf trees and shrubs which include: wax-myrtle (Myrica cerifera), bayberry (M. pensylvanica), dwarf sumac (Rhus copallina), poison ivy (Toxicodendron radicans), black cherry (Prunus serotina), American holly (Ilex opaca), greenbrier (Smilax spp.), groundsel bush (Baccharis halimifolia), loblolly pine (Pinus taeda), pitch pine (Pinus rigida), Virginia creeper (Parthenocissus quinquefolia), beach plum (Prunus maritima), and the non-native Japanese black pine (Pinus thunbergii).

A number of non-marine mammals, reptiles, amphibians and birds are associated with the dune habitat along the New Jersey coastline. These species include: Fowler's toad (Bufo woodhousei fowleri), eastern hognose snake (Heterodon platyrhinos), box turtle (Terrapene carolina), raccoon (Procyon lotor), eastern cottontail (Sylvilagus floridanus), red fox (Vulpes fulva), white-footed mouse (Peromyscus leucopus), meadow vole (Microtus pensylvanicus), white-tailed deer (Odocoileus virginianus), savannah sparrow (Passerculus sandwichensis), song sparrow (Melospiza melodia), mourning dove (Zenaida macroura), gray catbird (Dumetella carolinensis), northern mockingbird (Mimus polyglottos), and brown thrasher (Toxostoma rufum).

The back bays, Absecon Bay and Lakes Bay, are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. The low marsh zone is typically dominated by saltmarsh cordgrass (Spartina alterniflora). Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, molluscs and other organisms. Dominant species include sea lettuce (Ulva lactuca) and eelgrass (Zostera marina). The high marsh zone which is slightly lower in elevation than the transition zone is dominated by saltmeadow cordgrass and saltgrass (Distichlis spicata). This zone is typically flooded by spring high-tides. Plants typical of the transition zone include both upland and marsh species including marsh elder (Iva frutescens), groundsel-tree (B. halimifolia), bayberry (Myrica spp.), saltgrass (D. spicata), sea-blite (Sueda maritima), glasswort (Salicornia spp.), poison ivy (R. radicans), and common reed (P. australis).

4.6.2 Upper Beach

The upper beach or supralittoral zone typically lies below the primary dune and above the intertidal zone. An upper beach zone is present within the study area, however, it is subject to high disturbance from human activity. The upper beach zone is only covered with water during periods of extremely high tides and large storm waves. The upper beach habitat is characterized by sparse vegetation and few animals. This zone has fewer biological interactions than the dunes, and organic inputs are scarce. The most active organism in this zone is the ghost crab (Ocypode quadrata). This crab lives in semi-permanent burrows near the top of the shore, and it is known to be a scavenger, predator, and deposit sorter. The ghost crab is nocturnal in its foraging activities, and it remains in its burrow during the day. In addition to ghost crabs, species of sand fleas or amphipods (Talitridae), predatory and scavenger beetles and other transient animals may be found in this zone.

Many species of shorebirds inhabit the beach during the spring and fall migrations, although most are even more likely to be found on more protected sand and mud flats, tidal marshes, or along the Delaware Bay shoreline (especially in spring when large numbers of horseshoe crab eggs are available). Shorebirds feed on small individuals of the resident infauna and other small organisms brought in with waves. Common shorebird species include sanderling (Calidris alba), dunlin (C. alpina), semipalmated sandpiper (C. pusilla), western sandpiper (C. mauri), and willet (Catoptrophorus semipalmatus). Sanderling, dunlin, and western sandpiper also occur on the beach throughout the winter. Colonial nesting shorebird habitat is increasingly under pressure from development and human disturbance along New Jersey's Atlantic beaches. Nesting birds such as common tern (Sterna hirundo), least tern (Sterna antillarum), black skimmer (Rynchops niger), and American oystercatcher (Haematopus palliatus) are frequent spring and summer inhabitants on unvegetated dunes and upper beaches on Absecon Island.

Several species of gulls are common along New Jersey's shores, and are attracted to forage on components of the beach wrack such as carrion and plant parts. These gulls include the laughing gull (Larus atricilla), herring gull (L. argentatus), and ring-billed gull (L. delawarensis).

4.7 AQUATIC ECOLOGY OF AFFECTED AREA

4.7.1 Upper Marine Intertidal Zone

The upper marine intertidal zone is also primarily barren, however, more biological activity is present in comparison to the upper beach. Organic inputs are derived primarily from the ocean in the form of beach wrack, which is composed of drying seaweed, tidal marsh plant debris, decaying marine animals, and miscellaneous debris that washed up and deposited on the beach. The beach wrack provides a cooler, moist microhabitat suitable to crustaceans such as the amphipods: Orchestia spp. and Talorchestia spp., which are also known as beach fleas. Beach fleas are important prey to ghost crabs. Various foraging birds and some mammals are attracted to the beach fleas, ghost crabs, carrion and plant parts that are commonly found in beach wrack. The birds include gulls, shorebirds, fish crows, and grackles.

4.7.2 Intertidal Zone

The intertidal zone contains more intensive biological activity than the other zones. Shifting sand and pounding surf dominate a habitat which is inhabited by a specialized fauna. The beach fauna forms an extensive food-filtering system which removes detritus, dissolved materials, plankton, and larger organisms from in-rushing water. The organisms inhabiting the beach intertidal zone have evolved special locomotory, respiratory, and morphological adaptations which enable them to survive in this extreme habitat. Organisms of this zone are agile, mobile, and capable of resisting long periods of environmental stress. Most are excellent and rapid burrowers. Frequent inundation of water provides suitable habitat for benthic infauna, however, there may be a paucity in numbers of species. Intertidal benthic organisms tend to have a high rate of reproduction, and a short (1 to 2 years) life span (Hurme and Pullen, 1988). This zone contains a mixture of herbivores, primary carnivores, and some high order carnivores such as the mole crab (Emerita sp.). A number of interstitial animals (meiofauna) are present feeding among the sand grains for bacteria and unicellular algae, which are important in the beach food chain. In 1978, extensive sampling for invertebrate infauna was performed by the U.S. Fish and Wildlife Service and Corps of Engineers on the beaches within the Delmarva Peninsula, Maryland. There were four dominant species of invertebrate infauna in this zone, which were the mole crab (Emerita talpoida), a haustorid amphipod (Haustorius canadensis), the coquina clam (Donax variabilis), and spionid worm (Scolelepis squamata). The epifaunal blue crab (Callinectes sapidus) and the lady crab (Ovalipes ocellatus) were also found in or near this zone. These species withdraw to the nearshore subtidal zone during the winter months and return to the intertidal zone when conditions are more favorable. These invertebrates are prey to various shorebirds and nearshore fishes such as the Atlantic silverside (Menidia menidia), and juveniles of spot (Leiostomus xanthurus), kingfish (Menticirrhus saxatilus), and bluefish (Pomatomus saltatrix). The horseshore crab (Limulus polyphenus) is a common inhabitant of Atlantic Coastal areas, and utilizes the sandy beaches (particularly of Delaware Bay) to lay eggs.

Benthic macroalgae grow attached to the bottom substrate in the intertidal zone, where they are alternately exposed and submerged as the tides ebb and flow. The substrate along the Atlantic Coast of New Jersey is mainly composed of shifting sands and shell fragments, making it too unstable for large colonies of benthic algae to proliferate. Colonies do attach on hard, stable substrates provided by peat banks, shell bottoms, reefs, and man-made structures such as pilings, jetties, buoys and bridges. Various species of benthic macroalgae representing the phyla Chlorophyta and Phaeophyta are found in New Jersey's coastal waters.

The rock groins located along the Absecon Island oceanfront represent an artificial rocky intertidal zone. In addition to providing a hard substrate for the attachment of benthic macroalgae, the groins also contain suitable habitats for a number of aquatic and avian species. Barnacles, molluscs, small crustaceans, polychaetes, and a variety of shorebirds may reside on, above and around these structures. Mussels (Mytilus sp.) are prevalent on the rock surfaces. These structures are also used by various finfish for feeding and shelter.

4.7.3 Nearshore and Offshore Zones

The nearshore coastal zone generally extends seaward from the subtidal zone to well beyond the breaker zone (U.S. Army Corps of Engineers, 1984). This zone is characterized by intense wave energies that displace and transport coastal sediments. The offshore zone generally lies beyond the breakers, and is a flat zone of variable width extending to the seaward edge of the Continental Shelf. Hurme and Pullen (1988) describe the nearshore zone as an indefinite area that includes parts of the surf and offshore areas affected by nearshore currents. The boundaries of these zones may vary depending on relative depths and wave heights present (Figure 7).

The following paragraphs discuss planktonic, pelagic and benthic biological resources associated with New Jersey coastal waters, which may overlap nearshore waters with offshore waters. The proposed sand borrow sites for this project will be referred to as the proposed offshore borrow sites.

4.7.3.1 Plankton

Plankton are collectively a group of interacting minute organisms adrift in the water column. Plankton are commonly broken into two main categories: phytoplankton (plant kingdom) and zooplankton (animal kingdom).

Phytoplankton play an essential role in the food web because they are the primary producers in the aquatic marine ecosystem. Phytoplankton convert light and chemical energy into organic compounds which can be assimilated by higher organisms in the food chain. Phytoplankton production is dependent on light penetration, available nutrients, temperature and wind stress. Phytoplankton production is generally highest in nearshore waters. Seasonal shifts in species dominance of phytoplankton are frequent. Dinoflagellates are generally abundant from summer through fall, and diatoms are dominant during the winter and early spring. Approximately 126 species of phytoplankton were identified in New Jersey's coastal waters representing the following phyla: Chlorophyta, Chromophyta, Pyrrophyta, Euglenophyta, and Procaryota.

The most prevalent species and their season of dominance are as follows:

Nitzschia seriata - winter
Skeletonema costatum - late winter, early spring
Guinarkia flaccida - spring
Pyramimonas sp. - spring, early summer
Cryptomonas acuta - summer
Katodinium rotundatum - mid-summer
Chrysochromulina sp. - summer

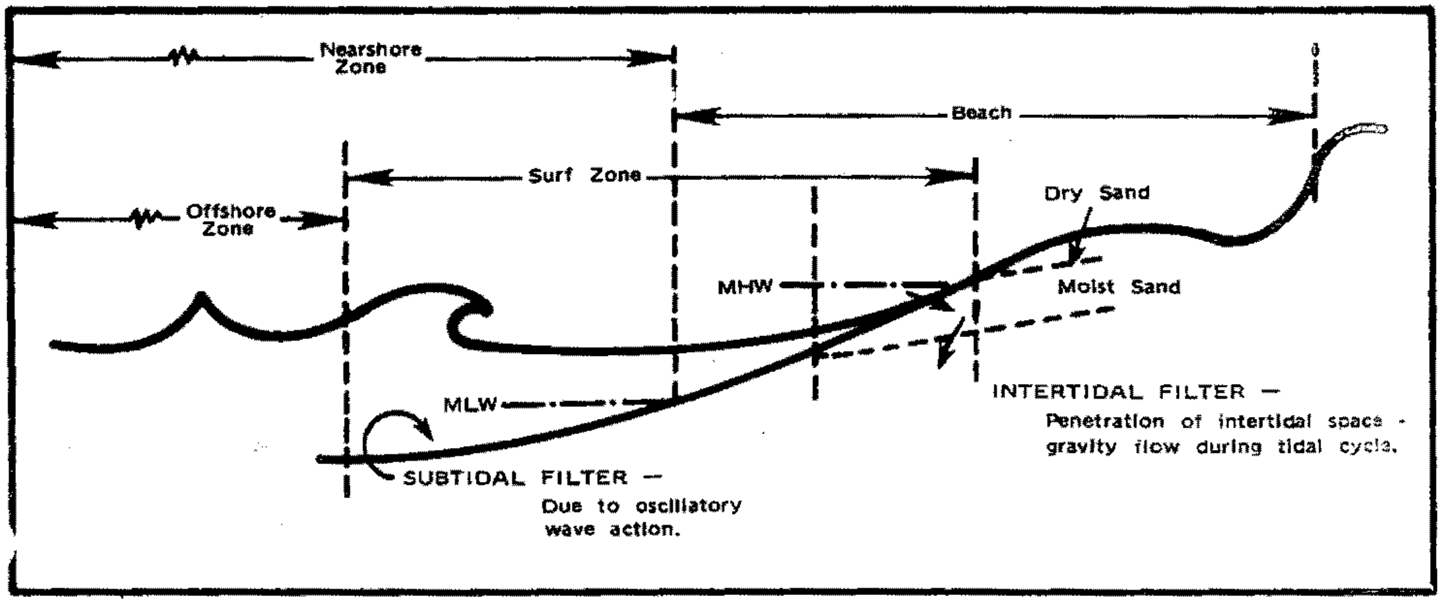


Figure 7. Zonation of beach and nearshore environments.

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Zooplankton provide an essential trophic link between primary producers and higher organisms. Zooplankton represent the animals (vertebrates and invertebrates) that are adrift in the water column, and are generally unable to move against major ocean currents. Many organisms may be zooplankton at early stages in their respective life cycles only to be able to swim against the currents (nektonic) in a later life stage, or to be a part of the benthic community. Zooplankton are generally either microscopic or barely visible to the naked eye. Zooplankton typically exhibit seasonal variances in species abundance and distribution, which may be attributed to temperature, salinity and food availability. In marine environments, seasonal peaks in abundance of zooplankton distinctly correlate with seasonal phytoplankton peaks. These peaks usually occur in the spring and fall. Sampling in the lower Delaware Bay by Watling and Maurer (1976) revealed the presence of 60 species representing the following phyla: Protozoa, Cnidaria, Ctenophora, Ectoprocta, Annelida, Mollusca, Arthropoda, Chaetognatha and Chordata. Zooplankton species characteristic of coastal areas include: Acartia tonsa, Centropages humatus, C. furatus, Temora longicornis, Tortanus discaudatus, Eucalanus pileatus, Mysidopsis bigelowi (mysid shrimp), and Crangon septemspinosa (sand shrimp).

4.7.3.2 Macroinvertebrates

The nearshore and offshore zones of the New Jersey Coast contain a wide assemblage of invertebrate species inhabiting the benthic substrate and open water. Invertebrate phyla existing along the coast are represented by Cnidaria (corals, anemones, jellyfish), Platyhelminthes (flatworms), Nemertinea (ribbon worms), Nematoda (roundworms), Bryozoa, Mollusca (chitons, clams, mussels, etc.), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), and the Urochordata (tunicates).

The diversity and composition of benthic communities are often reliable indicators of the overall quality of any particular habitat for supporting life (New Jersey Bureau of Fisheries, 1979). Benthic macroinvertebrates are those dwelling in the substrate (infauna) or on the substrate (epifauna). Benthic invertebrates are an important link in the aquatic food chain, and provide a food source for most fishes. Various factors such as hydrography, sediment type, depth, temperature, irregular patterns of recruitment and biotic interactions (predation and competition) may influence species dominance in benthic communities. Benthic assemblages in New Jersey coastal waters exhibit seasonal and spatial variability. Generally, coarse sandy sediments are inhabited by filter feeders, and areas of soft silt or mud are more utilized by deposit feeders.

Sampling associated with the proposed Atlantic Generating Station used clam dredges, trawls, and grab samples to survey the species composition, abundance, weight, and distribution of benthic macroinvertebrates in the vicinity of the Mullica River estuary, Great Bay, Little Egg Inlet, and the ocean from Brigantine Island to Lond Beach Island and 5 miles seaward (Milstein and Thomas, 1976). Over 250 macroinvertebrate species were collected during these surveys. These species included: Aricidea jeffreyssi (paraonid polychaeta), Spiophanes bombyx (spionid polychaeta), Tellina agilis (tellinid bivalvia), Mediomastus ambiseta (capitellid polychaeta), Nephtys picta (nephtyid polychaeta), Unciola irrorata (aorid amphipoda), Paranaitis speciosa (phyllodocid polychaeta), Nucula proxima (nuculid bivalvia), and Ensis directus (solenid bivalvia).

In 1979, the NJ Bureau of Fisheries conducted a benthic study in the inlets from Great Bay to Great Egg Harbor Inlet to inventory benthic organisms and the composition of the sediments in which they lived. The resulting report discussed the relationship of the organisms to sediment composition, as well as the condition of benthic communities in specific substrates. Although some species association was found with certain sediment types, no strong correlations between species diversity and density, and sediment composition were found (Fish and Wildlife Service, 1991).

In October 1994, a benthic-sediment assessment focusing on infauna species was conducted in the proposed offshore sand borrow sites located in Absecon Inlet and offshore of Absecon Inlet, to establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow site. Other objectives were to identify the presence of any commercial and/or recreationally important benthic macroinvertebrates, and to identify the presence of ecologically important benthic communities within the proposed sand borrow sites. Five control areas were situated around the proposed sand borrow site "A" (Absecon Inlet) and three around borrow site "B" (offshore area) to offer comparisons with the data. Figure 8 identifies the sample locations in relation to the proposed borrow site. The sediments inhabited by the benthic community were very sandy, with sand fractions ranging from 82.1 to 99.8 percent in area "A", and from 73.4 to 99.9 percent in area "B". Sediments from area "A" varied from poorly sorted to very well sorted. Proposed borrow area "B" sediments varied from moderately well sorted to very well sorted (Battelle Ocean Sciences, 1995).

The results of the benthic sampling from the 38 sample locations reveal that borrow area "A" is characterized by relatively low infaunal abundance (mean: 990 individuals/m^2) and low species diversity. Characteristic organisms included haustoriid amphipods, particularly Acanthohaustorius millsi and Protohaustorius sp. B. The archiannelid worm Polygordius was rare in this proposed borrow area. Area "B" was characterized by relatively high infaunal abundance (mean: 1700 individuals/m^2)

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and low speices diversity. Characteristic organisms in this area included Polygordius and Protohaustorius sp. B. This study also discovered the presence of the Atlantic surfclam Spisula solidissima at mean densities of about 10-20 individuals/m^2.

Total macrofaunal abundance per station in area "A" ranged from 20 individuals/0.1 m^2 at three stations to 260 individuals/0.1 m^2 at one station. Mean total abundance within borrow area "A" was 99 ($\pm$ 36) individuals/0.1 m^2. The contribution of major taxinomic groups varied within this area. Arthropods were the predominant component of 13 stations, contributing between 67 and 94% of the individuals present at those stations. Annelid worms were the most numerous major taxon at three stations, ranging from 47-52% of the individuals present. Table 10 shows the abundance of selected taxa within the areas sampled.

Differences in methodology between the present study and some published studies make direct comparison of results inappropriate. However, general comparisons are useful. Total infaunal abundance found during this study may be roughly compared to that found for an offshore sandy area near Delaware Bay (Maurer et al., 1979). The abundance recorded at the borrow areas proposed for Absecon Island (approximately 1400 to 1600 individuals/m^2) are higher than those reported by Maurer et al. (1979) for Hen and Chicken Shoals. They reported abundances ranging from about 100 to 700 individuals/m^2 for stations located at depths similar to those occurring in the Absecon Inlet Area. Samples studied by Maurer et al. (1979) were rinsed over a 1.0-mm mesh sieve while the Absecon samples were rinsed over a 0.5-mm sieve, thus abundances would be expected to be lower. The relative importance of haustoriid amphipods in the benthic communities in the Absecon Inlet area mirrors that found by Maurer et al. (1979). Maurer et al. (1979) also noted that species of haustoriids generally differed in their distribution relative to the shoreline. Acanthohaustorius millsi typically occurred in the nearshore area, while Parahaustorius longimerus occurred further offshore. In the Absecon Inlet areas, both species characterized relatively nearshore stations, while Protohaustorius sp B characterized offshore stations (Battelle Ocean Sciences, 1995). The complete benthic analysis can be found in Appendix A of the Main Report.

Since the time of the 1994 benthic sampling, another borrow area was added as a potential source of sand for this beachfill. This potential borrow area is located just offshore of Great Egg Harbor Inlet (Area C). In addition, another 76 acres were added to area "A" since the original benthic surveys were done. For this reason, a second round of benthic sampling was conducted for these areas in October 1995. In addition to the benthic surveys, a surf clam survey was also done for all three potential borrow areas.

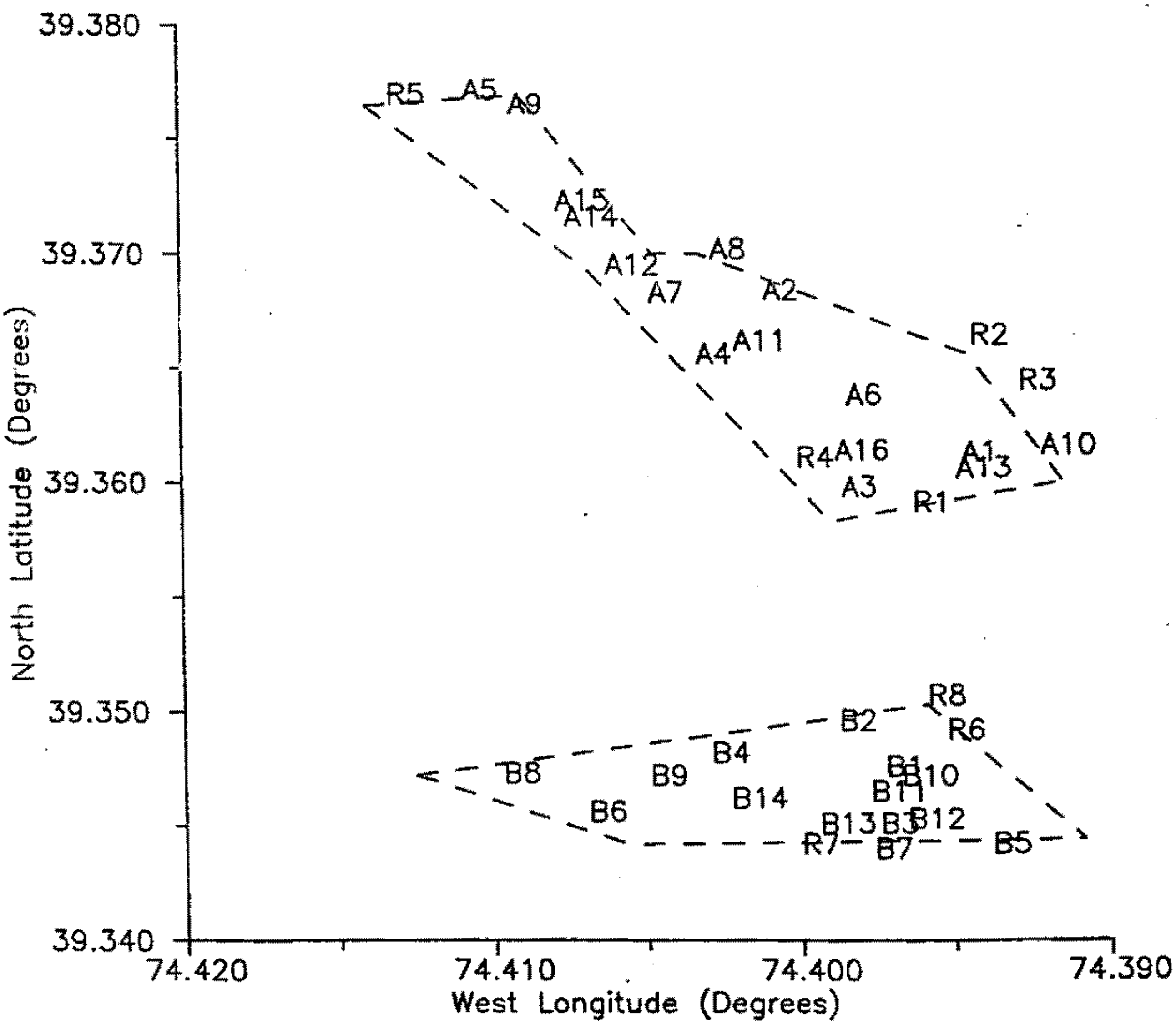

Figure 8
Benthic Sampling Locations

Table 10 Abundance (#/0.1 m^2) of selected taxa in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

Species	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16	Mean	STDS	95% CI
Magelona papillicornis	12	2	3	0	0	15	0	2	0	16	3	0	12	1	0	14	5.0	6.28	3.08
Scolelepis squamata	0	0	0	8	0	3	6	6	0	0	5	0	0	2	0	2	2.0	2.76	1.35
Polygordius	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0.2	0.54	0.27
Capitellidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.1	0.25	0.12
Acanthohaustorius millsi	14	22	24	22	3	43	22	2	4	6	12	37	55	0	2	71	21.2	20.88	10.23
Protohaustorius sp. B	68	8	1	0	0	55	0	0	0	116	0	0	111	0	0	63	26.4	41.90	20.53
Parahaustorius longimerus	0	7	4	36	10	4	59	4	0	0	31	48	2	6	9	2	13.9	18.77	9.20
Haustoriidae	116	58	33	102	15	120	103	8	5	141	63	101	180	7	15	167	77.1	59.49	29.15
Spisula solidissima	0	1	0	3	6	0	9	2	3	0	1	4	0	0	0	0	1.8	2.64	1.29
Pelecypoda sp. F	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	4.1	14.97	7.33

Species	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10	B-11	B-12	B-13	B-14	Mean	STDS	95% CI
Magelona papillicornis	0	34	1	3	35	1	17	14	16	0	0	14	0	0	9.6	12.49	6.54
Scolelepis squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.00	
Polygordius	142	27	9	24	64	0	89	2	19	18	22	262	32	281	70.8	93.32	48.88
Capitellidae	0	12	0	1	0	54	0	1	4	0	0	1	0	0	5.2	14.41	7.55
Acanthohaustorius millsi	0	6	0	0	4	1	2	5	6	0	0	4	0	0	2.0	2.45	1.28
Protohaustorius sp. B	0	87	0	61	26	0	0	41	57	0	1	2	1	1	19.8	29.64	15.53
Parahaustorius longimerus	1	0	3	0	0	0	0	0	0	2	2	4	4	0	1.1	1.56	0.82
Haustoriidae	1	111	3	68	39	1	7	47	70	3	4	27	8	2	27.9	34.57	18.11
Spisula solidissima	3	1	5	4	6	0	1	1	1	1	2	2	0	5	2.3	1.98	1.04
Pelecypoda sp. F	12	85	7	0	31	5	22	16	72	7	2	41	6	3	22.1	26.73	14.00

Species	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	Mean	STDS	95% CI
Magelona papillicornis	7	23	18	13	0	1	21	9	11.5	8.75	6.06
Scolelepis squamata	0	0	0	0	0	0	0	0	0.0	0.00	
Polygordius	0	0	2	0	5	33	38	3	10.1	15.82	10.96
Capitellidae	0	1	0	0	0	13	0	0	1.8	4.56	3.16
Acanthohaustorius millsi	49	30	15	32	0	0	10	5	17.6	17.69	12.26
Protohaustorius sp. B	23	131	98	17	0	0	1	97	45.9	53.66	37.18
Parahaustorius longimerus	5	1	0	4	0	0	2	0	1.5	2.00	1.39
Haustoriidae	87	180	127	81	0	0	19	102	74.5	64.39	44.62
Spisula solidissima	0	0	3	1	2	0	0	0	0.8	1.16	0.81
Pelecypoda sp. F	22	10	27	31	0	0	9	73	21.5	23.86	16.54

During the 1995 sampling, 13 stations were sampled within the proposed borrow areas as well as the surrounding areas (Figure 9). The results of this benthic analysis indicate a relatively low species richness in both borrow areas with the mean number of species not exceeding 11 in either borrow area. No significant differences were found between the borrow areas, between the borrow areas and the nearshore reference areas, or between the borrow areas and the Bight Apex area which was used as a reference (Versar, 1996). The abundance of species within the borrow areas was also relatively low, less than 2,000/m^2 (Table 11). Again, no statistically significant differences were detected between the borrow areas or between the borrow areas and the nearshore reference area. Total abundance in the Bight Apex area was significantly greater than in the borrow areas, by a factor of 17 to 40 (Versar, 1996). The difference is mostly due to a large abundance of a bivalve and two polychaetes in the Bight Apex area. These species are Nucula annulata (3,970/m^2), Polygordius spp. (13,006/m^2) and Prionospio steenstrupi (5,046/m^2).

The Versar report concluded that, except for the presence of surf clams, no significant attributes of the benthic community at the proposed borrow areas favor the selection of one borrow area over another. Also, measures of benthic community condition did not vary substantially between the proposed borrow areas and any of the reference sites in a way that would preclude the use of the areas.

The surf clam survey was conducted using a commercial hydraulic clam dredge equipped with a 72 inch knife to determine the abundance of clams in each borrow area. The areas were surveyed by conducting 3 five-minute tows within each proposed borrow area (Table 12). The results of these tows indicate that commerically harvestable quantities of clams exist within these areas. The highest concentration was found in area "B", where between 25 and 50 bushels of clams were collected during the 5-minute tows. The average number of clams per bushel was 156. The Great Egg Harbor borrow area "C", had numbers ranging from 11 to 40 bushels per tow, with an average of 232 clams per bushel. Potential borrow area "A" produced between 15 and 23 bushels per tow with an average of 145 clams per bushel (Versar, Inc., 1995). Figure 10 shows the size and age distribution of the sampled population. In borrow areas A and C, the size of the clams, in terms of lenght appears relatively evenly distributed in the range of 7-13 cm. Borrow area B however appears to contain a population between 5-10 years old with the average length 9-10 cm (Jones, et al., 1978).

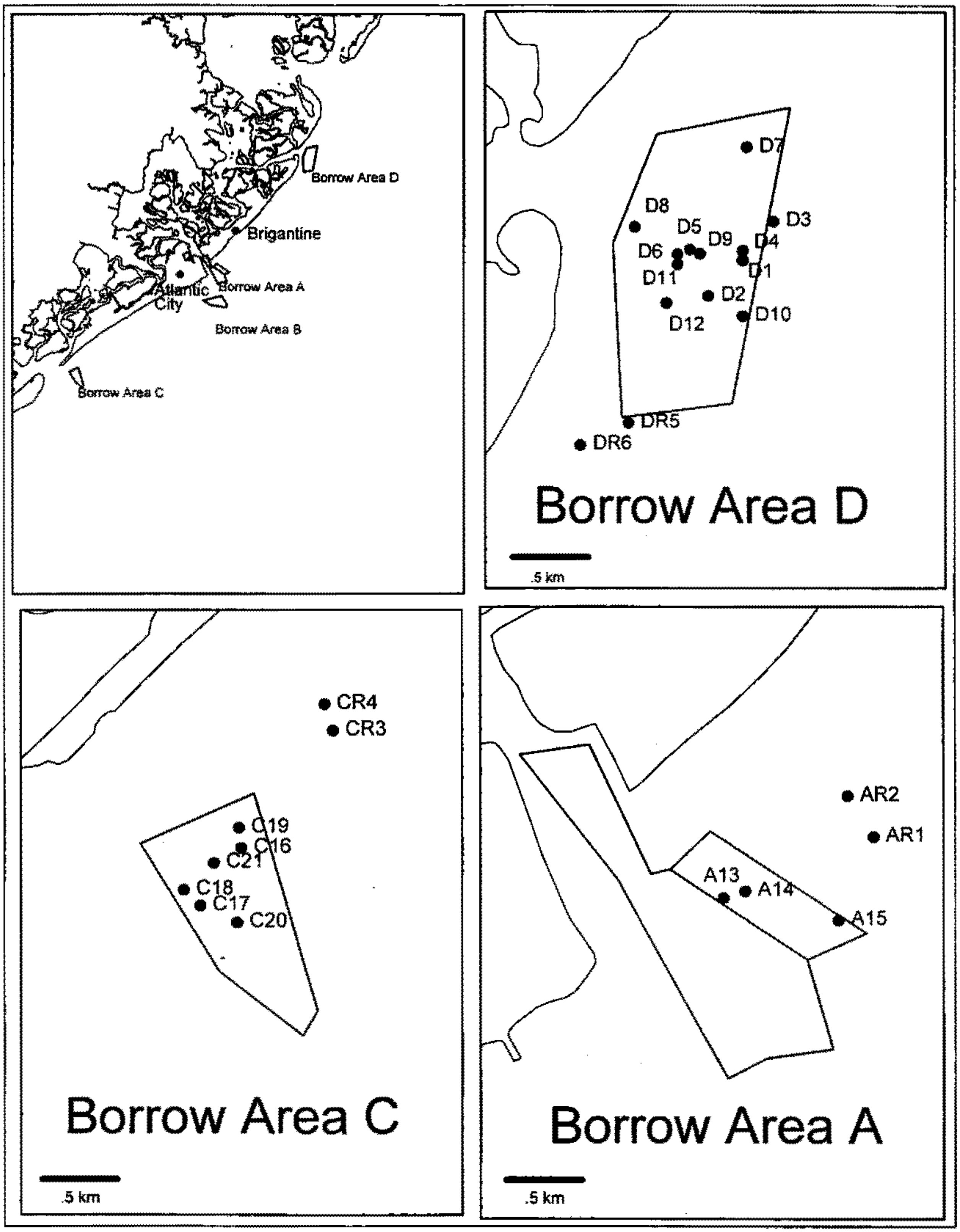

Figure 9
1995 Sample Locations

Mean abundance (#/m^2) of selected taxa at the borrow areas					
Species	**Borrow D**	**Borrow A**	**Borrow C**	**Nearshore Reference**	**Bight Apex Reference**
Nemertinea					
Nemertinea	7.58	7.58	11.36	15.15	90.49
Annelida : Polychaeta					
Ampharetidae	0	0	0	0	2,433.08
Apoprionospio pygmaea	0	22.73	7.58	18.94	0.84
Aricidea catherinae	0	0	0	0	513.47
Dispio uncinata	5.68	22.73	22.73	3.79	0
Euchone incolor	0	0	0	0	320.71
Lumbrineridae	0	0	0	0	327.86
Magelona spp.	28.41	53.03	155.30	64.39	31.99
Polygordius spp.	0	0	0	3.79	13,005.89
Prionospio steenstrupi	0	0	0	0	5,045.88
Tharyx sp. A Morris	0	0	0	0	411.20
Annelida : Oligochaeta					
Oligochaeta	0	0	0	3.79	911.20
Mollusca : Gastropoda					
Nassarius trivittatus	0	15.15	7.58	3.79	5.89
Mollusca : Bivalvia					
Donax variabilis	39.77	37.88	0	0	0
Nucula annulata	0	0	0	0	3,969.70
Petricola pholadiformis	0	0	0	15.15	0.84
Spisula solidissima	22.73	83.33	37.88	250.00	145.62
Tellina agilis	0	15.15	15.15	7.58	171.72
Arthropoda : Mysidacea					
Neomysis americana	1.89	7.58	0	18.94	0.84
Arthropoda : Tanaidacea					
Tanaissus psammophilus	1.89	15.15	11.36	0	52.19
Arthropoda : Isopoda					
Chiridotea coeca	18.94	0	0	0	0
Chiridotea tuftsi	0	0	11.36	0	0
Edotea triloba	1.89	22.73	30.30	11.36	16.84
Arthropoda : Amphipoda					
Acanthohaustorius millsi	54.92	431.82	181.82	231.06	1.26
Acanthohaustorius spp.	18.94	0	0	0	1.26
Ampelisca agassizi	0	0	0	0	281.57
Batea catharinensis	0	0	0	18.94	0
Bathyporeia quoddyensis	206.44	0	3.79	0	0
Bathyporeia spp.	9.47	7.58	11.36	7.58	0
Cerapus tubularis	0	0	0	90.91	0
Parahaustorius attenuatus	24.62	0	3.79	0	0
Parahaustorius longimerus	143.94	0	0	0	0
Parahaustorius spp.	172.35	0	7.58	0	0
Protohaustorius cf. *deichmannae*	28.41	1,106.06	1,261.36	795.45	60.61
Rhepoxynius hudsoni	0	0	11.36	0	65.24
Synchelidium americanum	0	7.58	11.36	15.15	0.42
Arthropoda : Decapoda					
Pagurus longicarpus	0	0	11.36	0	1.26

Table 11
1995 Sample Results

RESULTS OF THE BRIGANTINE CLAM SURVEY CONDUCTED ON OCTOBER 25, 1995								
BORROW AREA	LATITUDE	LONGITUDE	STATION	# OF CLAMS/ BUSHEL	# of BUSHELS	TOTAL CLAMS	DISTANCE TOWED (METERS)	DENSITY (CLAMS/M²)
BRIGANTINE INLET	39 26.42	74 18.38	D1	172	1.8	303.3	238	0.7
	39 26.58	74 18.26	D3	183	1.1	183.4	194	0.5
	39 26.26	74 18.45	D10	165	1.6	256.5	331	0.4
			AVG #	173.3				0.6
ABSECON INLET								
	39 21.78	74 23.27	A13	147	22	3182.7	272	6.4
	39 21.82	74 23.12	A14	148	15	2170	249	4.8
	39 21.72	74 23.03	A15	139	23	3327.3	310	5.9
			AVG #	144.7				5.7
ABSECON ISLAND OFF SHORE								
	39 20.56	74 23.98	B22	156	50	7800	307	13.9
	39 20.47	74 23.50	B23	112	37	5772	261	12.1
	39 20.59	74 24.06	B24	200	25	3900	217	9.8
			AVG #	156				11.9
GREAT EGG HARBOR INLET								
	39 17.74	74 30.91	C16	235	40	9280	264	19.2
	39 17.64	74 30.99	C17	221	11	2552	173	8.1
	39 17.63	74 31.01	C18	240	13	3016	125	13.2
			AVG #	232				13.5

Table 12
Results of Clam Survey

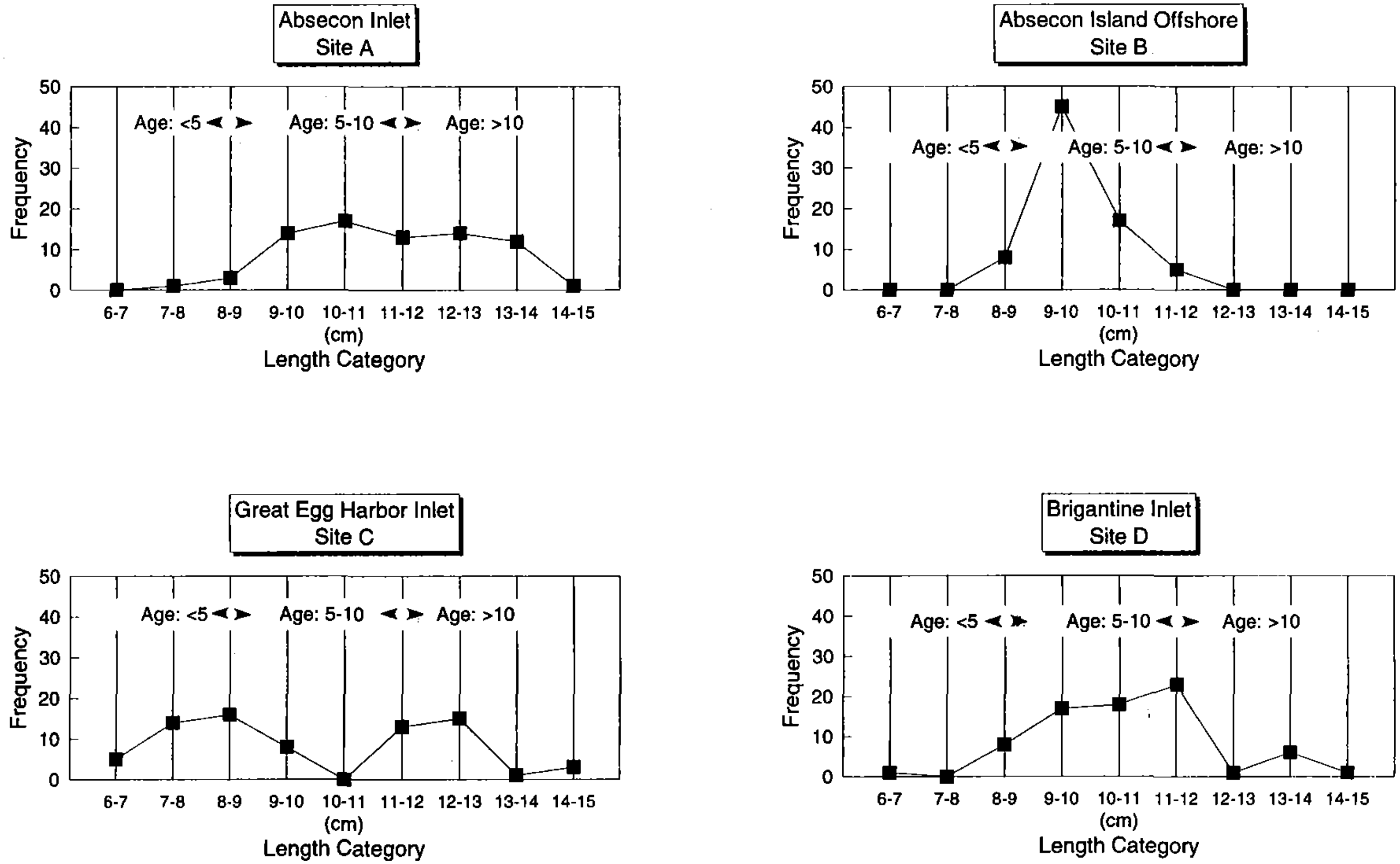

Figure 10
Size and Age Distribution of Surf Clams

4.7.3.3 Fisheries

4.7.3.3.1 Shellfish

Extensive shellfish beds, which fluctuate in qulaity and productivity are found in the back bays and shallow ocean waters of the study area. Surf clams (*Spisula solidissima*) are found offshore the barrier islands along with hard clams (*Mercenaria mercenaria*), blue mussel (*Mytilus edulis*) and blue crab (*Callinectes sapidus*). Since many of these animals are filter feeders and tend to bioaccumulate toxins and bacteria within their systems, bivalves are often used as indicators of water quality. Indications of this can be seen when shellfish areas are closed or have restricted harvests. In areas where this occurs, there are generally water quality or pollution problems associated with the closings.

The area between Little Beach and Absecon Inlet from the surf to one nautical mile off-shore has been designated a conservation zone by the Surf Clam Advisory Committee. This joint committee was formed by the N.J. Bureau of Shellfisheries and representatives of the commercial surf clam industry, to determine harvesting regulations. No surf clam harvesting is allowed within a conservation zone in order to promote recruitment and growth of current stock (U.S. Fish and Wildlife Service, 1991).

The waters behind Absecon Island and in the vicinity of Absecon Inlet are seasonal or special restricted. In special restricted areas, the waters are condemned for the harvest of oysters, clams, and mussels, except harvesting for further processing may be done under special permit from the New Jersey Department of Environmental Protection. Licensed clammers are allowed to relay clams to Great Bay where they cleanse themselves in purer waters. At the northern half of the island, the waters are classified as prohibited, and are condemned for the harvest of oysters, clams, and mussels from the shoreline to a distance between 0.25 miles and 2 miles. Most of Little Bay, Grassy Bay, and Reed Bay, except for isolated areas, are approved for shellfish harvest.

The surf clam fishery supports the largest molluscan fishery in New Jersey, accounting for, by weight, 52% of the State's total molluscan commercial landing in 1993. This catch represents over 85% of the total Mid-Atlantic area catch for 1993, with a value of over 21 million dollars (N.J. Bureau of Shellfisheries, 1994).

A study conducted from July 1989 to June 1990 surveyed the standing stock of surf clams in New Jersey (Ward, 1990). This study investigated size composition, abundance, and recruitment within the New Jersey surf clam population. In 1989, the harvest zones between Barnegat Inlet and Absecon Inlet were estimated to contain over 3 million bushels of surf clams, or 40% of the state's standing stock (Fish and Wildlife, 1991).

According to data from New Jersey's Bureau of Shellfisheries 1993 annual surf clam inventory project, the total surf clam standing stock for New Jersey territorial waters was 12,195,000 bushels. This number represents a decrease of 775,000 bushels from 1992. Surf clam harvest records indicate that most of the harvesting activity (42%) in New Jersey occurred in the middle mile between Absecon Inlet and Barnegat Inlet. During the 1993-1994 season, over 600,000 bushels of surf clams were harvested (N.J. Bureau of Shellfisheries, 1994).

The hard clam is the most economically important shellfish of the back bays, supporting both commercial and recreational fisheries (N.J. Bureau of Fisheries, 1979). Although data on exact locations and densities of adult hard clams within the project area is limited, they are known to be found in the intertidal and subtidal zones of bays and lower estuaries. A hard clam survey conducted in 1990 found areas with moderate (0.20 - 0.49 clams/sq. ft.) to high densities ($\geq$ 0.50 clams/sq. ft.) in the areas behind Brigantine Island (Joseph, 1990).

In addition to supporting some of the best hard clam resources in the State, the bays in the project area also support other species of shellfish (N.J. Bureau of Fisheries, 1979). American oysters are not usually present in commercially harvestable densities, but can be found throughout the project area. Soft clams and blue mussels are primarily harvested for recreation, but occasionally commercial densities are present (Fish and Wildlife, 1991).

4.7.3.3.2 Finfish

The proximity of several embayments allows the coastal waters of New Jersey to have a productive fishery. Many species utilize the estuaries of Absecon Bay, Reeds Bay and Lakes Bay for forage and nursery grounds. The finfish found along the Atlantic Coast of New Jersey are principally seasonal migrants. Winter is a time of low abundance and diversity as most species leave the area for warmer waters offshore and southward. During the spring, increasing numbers of fish are attracted to the New Jersey Coast, because of its proximity to several estuaries which are utilized by these fish for spawning and nurseries.

A study, conducted from March to December 1977 by John F. McClain and presented in "Studies of the Back Bay Systems in Atlantic County," indicates that the back bays of the Atlantic City area provide a high quality habitat for many species of fish. Fifty-nine species of fish, including bay anchovy (Anchoa mitchilli), weakfish (Cynoscion regalis), spot (Leiostomus xanthurus), windowpane (Scophthalmus aquosus), red hake(Urophycis chuss), winter flounder (Psuedopleuronectes americanus), small mouth flounder (Etropus microstomus), oyster toadfish (Opsanus tau) and Atlantic silverside (Menidia menidia), were among the species utilizing this habitat. The fish species caught in the back bays during this study are summarized in Table 13.

Sampling was conducted by gill net, seine and trawl. The bay anchovy was present at all trawl stations and dominant in six of them, while the seine samples were dominated by the Atlantic silverside at all stations except one. The fish species and their relative abundance were found to be similar to those reported in studies for Great Bay and Brigantine National Wildlife Refuge, now the Forsythe National Wildlife Refuge, (Icthyological Associates, 1974 and 1975), and the Delaware Bay (Daiber, 1974). The five most abundant species were Atlantic silverside, bay anchovy, spot, mummichog (3%) and striped killifish (1%).

During a 1977 ichthyoplankton study, conducted by Peter Himchak and presented in "Studies of the Back Bay Systems in Atlantic County", twenty species of larval and young finfish were found to utilize the backbays in the vicinity of Atlantic City as a nursery area. These include species endemic to estuaries as well as marine species that utilize the back bays as nursery grounds. Over 80 percent of the catch was comprised of members of the Gobiidae and Engravlidae Families. Approximately 15 percent of the total catch was comprised of naked gobies (Gobiosoma bosci), Northern pipefish (Syngnathus fuscus), weakfish (Cynoscion regalis), and bay anchovies (Anchoa mitchilli).

From 1972 to 1975, an intensive ecological study was conducted for the proposed Atlantic Generating Station (U.S. Fish and Wildlife Service, 1991). Trawl surveys between Holgate Peninsula and Brigantine Inlet collected 69 species in 1972, and 76 species in 1973 and 1974. The most abundant fish taken for all years included bay anchovy (Anchoa mitchilli), red hake (Urophycis chuss), windowpane flounder (Scophthalmus aquosus), weakfish (Cynoscion regalis), spotted hake (Urophycis regia), and silver hake (Merluccius bilinearis).

One hundred seventy-eight species of saltwater fishes are known to occur in waters of nearby Peck Beach. Of these, 156 were from nearshore waters. Of the 124 species recorded in nearby Great Egg Harbor Inlet, 28 are found in large number in offshore waters.

Table 13. Fish Species Caught in the Back Bays of Atlantic City- March-December 1977.

Species	Scientific Name
Haddock	Melanogrammus aeglefinus
Mummichog	Fundulus heteroclitus
American Sand Lance	Ammodytes americanus
Black sea bass	Centropristis striata
Northern pipefish	Syngnathus fuscus
White Hake	Urophycis tenuis
Spot	Leiostomus xanthurus
Striped sea robin	Prionotus evolans
Weakfish	Cynoscion regalis
Winter flounder	Psuedopleuronectes americanus
Striped killifish	Fundulus majalis
American eel	Anguilla rostrata
Northern sea robin	Prionotus carolinus
Smallmouth flounder	Etropus microstomus
Striped mullet	Mugil cephalus
Striped anchovy	Anchoa hepsetus
Atlantic menhaden	Brevoortia tyrannus
Spotted hake	Urophycis regius
Northern stingray	Dasyatis sp.
American shad	Alosa sapidissima
Banded killifish	Fundulus diaphanus
Threespine sticklebak	Gasterosteus aculeatus
Permit	Trachinotus falcatus
Crevalle jack	Caranz hippos
Fourspine stickleback	Apeltes quadracus
Orange filefish	Aluterus schoepfi
Pollock	Pollachius virens
Bay anchovy	Anchoa mitchilli
Cunner	Tautogolabrus adspersus
Northern puffer	Sphoeroides maculatus
Smooth dogfish	Mustelus canis
Striped cusk eel	Rissola marginata
Summer flounder	Paralichthys dentatus
Windowpane	Scophthalmus aquosus
Atlantic roasker	Micropogon undulatus
Red Hake	Urophycis chuss
Blueback herring	Alosa aestivalis
Lookdown	Selene vomer
Oyster toadfish	Opsanus tau
Striped burrfish	Chilomycterus schoepfi
Bluefish	Pomatomus saltatrix
Alewife	Alosa pseudoharengus
Hardtail	Caranx crysos
Hogchoker	Trinectes maculatus
White perch	Morone americana
Atlantic silverside	Menidia menidia
Sheepshead minnow	Cypinodon variegatus

4.7.4 Inland Bays

Like many of the barrier islands along the coast of New Jersey, the Absecon Island study area is bordered by inland embayments. The two embayments which are located on the western side of Absecon Island are Absecon Bay and Lakes Bay. The inland bays are bordered extensively with tidal marshes composed of saltmarsh cordgrass (Spartina alterniflora), saltmeadow hay(S. patens), spike grass (Distichlis spicata), and high tide bush (Iva frutescens).

Common estuarine fishes present in the inland bays include: bay anchovy (Anchoa mitchilli), Atlantic silverside (Menidia menidia), mummichog (Fundulus heteroclitus), striped killifish (Fundulus majalis), naked goby (Gobiosoma bosci), and hogchoker (Trinectes maculatus). The inland bays are important nurseries for a variety of commercial and recreational fishes including: spot, croaker, weakfish, menhaden, bluefish, and summer flounder. The bays support adequate numbers of hard clam (Mercenaria mercenaria) and blue crab (Callinectes sapidus) for recreational and/or commercial fisheries. The inland bays are also important for supporting a variety of waterfowl, shorebirds, and wading birds.

4.8 ENDANGERED AND THREATENED SPECIES

Federally designated endangered and threatened species found within the study area include the endangered bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), Kemp's Ridley turtle (Lepidochelys kempii), hawksbill turtle (Eretmochelys imbricata), leatherback turtle (Dermochelys coriacea); and the threatened piping plover (Charadrius melodus), green turtle (Chelonia midas), and loggerhead turtle (Caretta caretta). Peregrines utilize coastal beaches and salt marshes within the study area extensively during migration, and to a lesser extent in summer and winter. Migrating and overwintering bald eagles utilize the study area's coastal marshes where they feed on waterfowl. However, no eagles are known to nest in the area. The highest plover use occurs on the southern tip of Brigantine Island along Absecon Inlet, and the adjacent ocean-front beaches.

A number of Federal or State endangered or threatened species may occur in the vicinity of the study area. Eleven threatened or endangered bird species may occur within the study area. The State endangered species occurring in the Atlantic City area include osprey (Pandion haliaetus), least tern (Sterna albifrons), and black skimmer (Phynchops nigra). The Federally endangered peregrine falcon (Falco peregrinus), and bald eagle (Haliaeetus leucocephalus), along with the State endangered Cooper's hawk (Accipiter cooperi) are migrant species. The State threatened species include marsh hawk (Circus hudsonius) and short-eared owl (Asio flammeus) as winter residents, the pied-billed grebe (Podilymbus podiceps) and great blue heron (Ardea herodias) as both winter and summer residents, and the migrant merlin (Falco columbarius).

Several species of threatened or endangered sea turtles and whales occur in the coastal and nearshore waters of the study area, although all are transients. The endangered hawksbill turtle (Eretmochelys imbricata), leatherback turle (Dermochelys coriacea), and Atlantic ridley turtle (Lepidochelys kempii), and the threatened loggerhead turtle (Caretta caretta), and green turtle (Chelonia mydas) are five species of sea turtles believed to occur in the nearshore waters of the Atlantic Ocean and bay waters. Six species of endangered whales migrate through the North Atlantic and may be found off the coast of New Jersey. These are the blue whale (Balaenoptera physalus), finback whale (Balaenoptera physalus), humpback whale (Megaptera novaeangliae), right whale (Eubalaena spp.), sei whale (Balaenoptera borealis), and sperm whale (Physeter catodon).

4.9 WILDLIFE RESOURCES

Marsh complexes along the New Jersey coast provide a valuable nesting habitat for the seabird population, including the common tern (Sterna hirundo). Common species occupying dredged material disposal areas, especially older sites that have been revegetated, are the least tern (Sterna albifrons), great black-backed gull (Larus marinus), herring gull (Larus argentatus), and the gull-billed tern (Gelocheliodon nilotica), which seek out those sites that have reverted to saltmarsh. Since the least tern is limited to a sandy substrate, unvegetated dredged material islands provide an alternative to barrier island beach habitats. The common tern occupies marsh habitats almost exclusively, while the laughing gull is found on both marsh and disposal sites. Although extensive development and disturbance of the natural conditions of the barrier islands has made this habitat the least utilized, wading birds, such as the great egret (Casmerodius albus), black-crowned night heron (Nycticorax nycticorax), and yellow-crowned night heron (Nyctanassa violacea), are known to inhabit the barrier islands. The snowy egret (Leucophoyx thula), glossy ibis (Plegadis Falcinellus) and little blue heron (Florida caerulea) occupy dredged material islands. Wading birds will typically arrive in mid-March and remain until mid-fall, when they travel south.

The New Jersey coast in the vicinity of the study area is also known as an important wintering ground for a number of waterfowl species. Species include the Atlantic brant (Branta bernicla), black duck (Anas rubripes), Canada goose (Branta canadensis), snow goose (Chen hyperborea), widgeon (Marela americana), scaup (Aytha spp.) and scoter (Melanitta spp.). Over 35 percent of the Atlantic Flyway American black duck (A. rubripes) wintering population utilizes the coastal marshes of New Jersey.

A 1989 survey of the Atlantic coast of New Jersey found 14 species of colonial waterbirds nesting in 39 separate colonies in the Reeds Bay/Absecon Bay area. The survey noted that black-crowned and yellow-crowned night heron populations have declined in the last decade, while egret, ibis, and gull populations have remained stable or increased (U.S. Fish and Wildlife Service, 1991).

Several species of marine mammals, such as the harbor seal (Phoca vitulina), grey seal (Halichoerus grypus), ringed seal (P. hispida), harp seal (P. groenlandica), and hooded seal (Cystophora cristata), are occasionally seen in the bay areas between December and June. Bottle-nosed dolphin (Tursiops truncatus) are commonly seen in Absecon Inlet in the summer, while striped dolphin (Stenella coeruleoalba) and harbor porpoise (Phocoena phocoena) are occasionally observed in the spring. Other marine mammals that occur in the area include right whale (Balaena glacialis), pilot whale (Globicephela macrorhynchus), pygmy sperm whale (Kogia breviceps), Atlantic white-sided dolphin (Lagenorhynchus acutus), and Risso's dolphin (Grampus griseus).

According to studies conducted at the Forsythe National Wildlife Refuge, mammals occurring along streams and on the marsh near woodlands, in and around the study area, include the opossum (Didelphia marsupialis), shorttail shrew (Blarina brevicauda), least shrew (Cryptotis parva), starnose mole (Condylura cristata), and masked shrew (Sorex cinereus). Bat species sighted along watercourses and in wooded areas include the little brown bat (Myotis lucifugus), silver-haired bat (Lasionycteris noctivagans), Eastern pipstrel (Pipistrellus subflavus), big brown bat (Eptescius fuscus), and red bat (Lasiurus cinereus). Upland fields and woodlands support the Eastern chipmunk (Tamias striatus), Eastern cottontail (Sylvilagus floridanus), various mice and vole species, muskrat (Ondatra zibethicus), raccoon (Procyon lotor), longtail weasel (Mustela frenata) and mink (Mustela vison). In addition, gray fox (Urocyon cinereoargenteus) and river otter (Lutra canadensis) have been identified on colonial seabird islands.

A number of upland and fresh water species of reptiles and amphibians occur in the study area. Common reptiles include the following turtles and snakes: the snapping turtle (Chelydra serpentina), stinkpot (Sternothaerus odoratus), Eastern mud turtle (Kinosternos subrubum), Eastern box turtle (Terrapene carolina), diamond back terrapin, Eastern painted turtle (Chrysemys picta), northern watersnake (Natrix sipedon), Eastern garter snake (Thamnophis sirtalis), Northern black racer (Coluber constrictor), and Northern redbellied snake (Storeria occipitomaculata). The redbacked salamander (Plethodon cinereus), four-toed salamander (Hemidactylium scutatum), Fowler's toad (Bufo woodhousei), Northern spring peeper (Hyla crucifer), New Jersey chorus frog (Pseudarcrus triseriata), green frog (Rana utricularia), and Southern leopard frog (Rana pipiens) are all common species of amphibians found in the area.

4.10 CULTURAL RESOURCES

In preparing the FEIS, the Corps has consulted with the New Jersey State Historic Preservation Office (NJSHPO) and other interested parties to identify and evaluate historic properties in order to fulfill its cultural resources responsibilities under the National Historic Preservation Act of 1966, as amended through 1992, and its implementing regulations, 36 CFR Part 800. As part of this work, cultural resources investigations were conducted in the project area. The results of these studies are presented in a draft report entitled "A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey" (Cox and Hunter, 1995) and in an executive summary entitled "Phase 1 and 2 Submerged and Shoreline Cultural Resources Investigation, Brigantine to Hereford Inlet, Atlantic and Cape May Counties, New Jersey" (Cox 1995)(see Appendix A of the Main Report). Section 106 consultation with the NJSHPO for project review has been completed (see Appendix D). The following discussion is taken largely from the above referenced draft reports.

4.10.1 Prehistoric Resources.

The prehistoric occupation of the barrier islands and adjacent Atlantic coastal regions has been categorized by archaeologists into three general periods of cultural development: Paleo-Indian (15,000 years before present (B.P.) - 8,500 B.P.), Archaic (8,500 B.P. - 5,000 B.P.), and Woodland (5,000 B.P. - 400 B.P.). The Paleo-Indian period is the time of the earliest human occupation of the region. Evidence of Paleo-Indian occupation in New Jersey is generally in the form of isolated fluted point sites. This is partly due to the low population density and nomadic lifestyle of the people from the period, as well as from the inundation of sites by sea level rise. Absecon Island was not a coastal location at the time of Paleo-Indian occupancy, but was the site of inland forest/riverine habitats. The shoreline achieved its current location approximately 3,000 years ago.

Archaic period peoples responded to the changing environmental conditions of the post-Pleistocene by exploiting a greater variety of resources. Archaeological investigations have shown that Archaic period sites tend to be relatively small, suggesting short-term and intermittent occupations in areas adjacent to interior freshwater swamps and bay/basin locations. Coastal tidal salt marshes and estuarine environments remained food resource-rich habitats available for exploitation. The prehistoric period that is best represented is the Woodland period, which is characterized by the introduction of pottery, increasing cultural diversity, and the evolution of a sedentary lifestyle that increasingly relied on agriculture. Woodland period culture remained intact until European contact. Woodland period sites have been identified on both the coastal marshes and in the mid-drainage areas in the region. Archaeological sites from this period produce distinctive ceramic forms and small triangular projectile points indicative of bow-and-arrow technology. There are no reported prehistoric sites within the current limits of the project area. The closest known sites are located more than three miles from Absecon Island in Pleasantville and near Linwood.

4.10.2 Historic Resources.

European settlement in the Absecon Island vicinity was informally initiated by Swedish pioneers in the mid-17th century when the small hamlet Lower Bank was established within 20 miles of Atlantic City on the north side of Mullica River. The first formal land surveys in the vicinity of Absecon Island were conducted at the end of the 17th century. In a 1695 survey, Absecon Inlet is referred to as "Graverads Inlet". The region soon developed a strong shipbuilding tradition. Census records indicate that by 1850 shipbuilding was the leading "mechanical business" being conducted at Absecon. The small schooner, especially suited for the lumber and charcoal trade, was the leading ship type built in the region.

Prior to the completion of the Camden and Atlantic Railroad in 1854, Absecon Island remained largely undeveloped. Jeremiah Leeds and his family owned much of Absecon Island up to the mid-19th century, when his heirs began selling property to the Camden and Atlantic Railroad Company for resort-based residential development. The C & A Railroad completed the rail connection from Camden to Absecon Island in 1854. A bridge was completed the following year connecting the barrier island to the main land. The impact of the C & A Railroad and other railroads that followed was dramatic. Multiple rail access effectively enabled Atlantic City to emerge as New Jersey's premier resort location. By 1900, the island had a population of 28,000. Longport and South Atlantic City continued to expand and the city of Ventnor became well established.

The original idea for the Atlantic City boardwalk dates to 1870 when the City Council passed a resolution to build the first boardwalk. This first structure was elevated 18 inches above the sand and could be disassembled and put in storage during the winter months. The first permanent boardwalk was erected in 1884 and was the first such structure to be equipped with electricity. The present ocean-front structure, composed of steel pilings and steel girders, is the fifth boardwalk, and was built by the Phoenix Bridge Company in 1939. As early as the 1880's, the prospect of entertainment piers extending from the boardwalk out into the sea was envisioned. The Steeplechase Pier, first known as the Auditorium Pier, was constructed in 1899. It was rebuilt in 1904 to include a bandshell and was totally rebuilt following a fire in 1932. In the 1960's it became the first amusement pier to reintroduce the roller coaster as an attraction. The Garden Pier was built between 1912 and 1914, and supported 25 stores and a large four-towered building containing a ballroom, a theater and an exhibition hall centered around a garden court. In 1940, after years of financial problems, the city took possession of the pier and converted it into a new civic center in 1955.

Atlantic City prospered into the first quarter of the 20th century. In 1920 the Convention Hall was opened and became the National Headquarters of the Miss America Pageant. The surging economy of Atlantic City encountered its first major setback when the stock market crashed in 1929. The city was devastated and, to this day, has yet to fully recover its former glory as the nation's premiere sea-side resort. The city is currently relying on casino gambling as the basis for economic recovery, however, the city's permanent population has been in steady decline, while that of the neighboring towns of Ventnor, Margate and Longport has been increasing.

4.10.3 Maritime History

Absecon Inlet was developed as the harbor for Atlantic City in the late 19th century. Although merchants in the region had long used the inlet to transport lumber, ice, coal, brick, stone, oysters and other items to and from the various beachfront and interior communities, by the end of the 19th century the inlet was principally used by pleasure and fishing craft. Navigational improvements to the inlet were not completed until the late 19th century, and navigation through the high-energy environment of the inlet remained treacherous throughout this period. Coastal storms rapidly moved sand in and out of the inlet, causing severe hazards to shipping. The U.S. Army Corps of Engineers constructed a jetty on the northeast side to stabilize the channel, and also dredged the channel to a depth of 12 feet in 1912.

Although there are no major Atlantic coastal ports in New Jersey, there has been a consistently high volume of ship traffic passing up and down the coast in route to the port cities in New York Bay and Delaware Bay throughout the historic period. The barrier beaches and inlets along the 127-mile New Jersey coastline offer little relief to mariners in distress, and

Absecon Inlet was one of only a few suitable harbors in which to seek refuge. Entering the inlet during a coastal storm was quite hazardous, and a number of vessels have been documented as being lost in the vicinity. Over three hundred vessels have been wrecked on the shoals off Brigantine and Absecon Islands since the late 1700's. Coastal storms, treacherous northeast winds and swift tidal currents, coupled with historically heavy coastal traffic, has caused the documented loss of dozens of sailing vessels, steamships, barges, tugs and large modern ships off the New Jersey Coast. A variety of potential submerged cultural resources in the project vicinity could date from the first half of the 17th century through the Second World War. The 1990 NOAA chart and U.S.G.S. quadrangle maps for the project area show numerous shipwreck sites on the shoals and just off the shoreline. Federal funding for navigation aids and life saving stations occurred in the 19th century. In 1857 the Absecon Lighthouse was constructed at the northeast end of Atlantic City. The first Federal appropriation for lifesaving stations in New Jersey occurred in 1848, when $10,000 was set aside to provide lifeboats and rockets for eight lifeboat stations. By 1900 there were 42 lifesaving stations on the New Jersey coast at an average of three miles apart. Absecon Island had three lifesaving stations - numbers 27, 28 and 29. Station records from 1886 to 1897 show that 139 vessels were in distress off Absecon Inlet during those 11 years.

4.10.4. National Register Properties

There are numerous historic properties listed on the National Register of Historic Places within the general project vicinity. These include the Absecon Lighthouse and several hotels, apartment buildings, churches, and the Marvin Gardens Historic District. Two properties, the Atlantic City Convention Hall and Lucy, the Margate Elephant, have been designated National Historic Landmark status.

4.10.5. Cultural Resources Investigations

The Philadelphia District conducted two cultural resources investigations for the project in 1995. In the first study, entitled "A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey (Cox and Hunter 1995), researchers investigated two offshore borrow areas and an eight-mile segment of tidal zone shoreline along Absecon Island. Magnetometer, side-scan and bathymetric data analysis identified 5 potentially significant underwater resources in the Absecon Inlet Borrow Area. No targets of any kind were identified in the Offshore Borrow Area. The shoreline survey identified two historic entertainment piers that are potentially eligible for listing in the National Register of Historic Places - the Steeplechase Pier and the Garden Pier.

In the second study, submitted as an executive summary entitled "A Phase 1 and 2 Submerged and Shoreline Cultural Resources Investigation, Brigantine Inlet to Hereford Inlet, Atlantic and Cape May Counties, New Jersey" (Cox 1995), archaeologists conducted an additional remote sensing survey in the borrow area at Absecon Inlet, a remote sensing survey at a new offshore borrow area at Longport, and underwater ground truthing operations at selected high probability target locations in the Absecon Borrow Area. This second remote sensing survey identified two additional and potentially significant targets in the Absecon Inlet Borrow Area, bringing the total number of high probability targets in this one borrow area to seven. Underwater ground truthing operations were conducted at 6 of these 7 target locations. One target was not investigated during ground truthing operations. Although site conditions in the inlet limited the ability of the divers to confirm the material responsible for generating each target, a re-analysis of previously collected and newly acquired remote sensing data suggests that 5 of the 7 targets located in the Absecon Borrow Area exhibit strong shipwreck characteristics. Historical research shows that one of these targets, although not confirmed in the field, is the probable location of the 85 foot barge "Troy", a modern vessel that sank in the inlet in the early 1980's.

No remote sensing targets were found in the Longport or the Offshore borrow areas.

4.11 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES (HTRW)

In accordance with ER 1165-2-132 entitled Hazardous, Toxic and Radioactive Wastes (HTRW) Guidance for Civil Works Projects, dated 26 June, 1992, the Corps of Engineers is required to conduct investigations to determine the existence, nature and extent of hazardous, toxic and radioactive wastes within a project impact area. Hazardous, toxic and radioactive wastes (HTRW) are defined as any "hazardous substance" regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq, as amended. Hazardous substances regulated under CERCLA include "hazardous wastes" under Section 3001 of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 et seq; "hazardous substances" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, "hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412, and "imminently hazardous chemical substances or mixtures" that EPA has taken action on under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606.

An HTRW literature search was conducted for Absecon Island by HRP Associates, Inc. for the U.S. Army Corps of Engineers Philadelphia District. The literature search identified 17 documented or potential HTRW sites in the project area, all located on Absecon Island (see Appendix A of the Main Report).

The preliminary assessment was divided into two sections. Both sections independently evaluated the impacts of the 17 potential HTRW sites identified. The first section discusses the impacts of the sites on potential offshore borrow areas. The second section evaluates the impacts of the sites on construction which requires excavation (for example, bulkhead replacements, outfall extensions and groin construction) that may take place on Absecon Island itself.

Three potential offshore borrow areas have been identified for Absecon Island. These three borrow areas are Absecon Inlet, a linear shoal offshore of Atlantic City, and the northern portion of Great Egg Harbor ebb shoal. A number of the documented HTRW can be eliminated from concern due to the fact that 1) there are hydraulic "disconnects" between the mainland and the borrow area (channels, inlets and general topography), and 2) there are no driving heads to propagate the spread of contamination. The conclusion that groundwater is not a vehicle for contaminant transport into the borrow areas can be drawn. As such, contaminant concerns for the above sites where groundwater is the main method of contaminant transport can be eliminated.

The borrow area in Absecon Inlet is proximal to 17 reported fuel spills in Clam Creek. The method for contaminant transport in this instance would be the tide and currents. The sediments in the borrow area are recent, and are continually reworked by the offshore environment. As such it is not believed that fuel spills in Clam Creek could have any significant impact on sediment quality in Absecon Inlet.

Lastly, the linear shoal offshore of Atlantic City is proximal to the reported location of the ordnance-explosive waste site (8). In 1961, and at this location, the U.S. Navy lost an undetermined amount of TNT charges in 27 feet of water. However, since the charges were not for underwater use and the borrow area does not intersect the area of concern shown on NOAA chart 12318, site 8 was eliminated from concern.

A number of potential HTRW sites were documented on Absecon Island. However, all of the sites except one were eliminated from concern for various reasons.

Some of the sites were eliminated due to the fact that they are beyond the project's limits. Other sites were eliminated due to the fact that the recommended plan in proximity to these sites will not include excavation, and as such the project would not affect any HTRW . And lastly, 2 sites were eliminated due to the fact that they are located offshore, and as such will not be affected by landbased construction.

One site lies near the location of a proposed bulkhead on Absecon Inlet. Therefore, this site, which is curently a vacant lot with a leaking underground storage tank (LUST), was not eliminated from concern. However, excavation in this area would be minimal, especially excavation below the ground water table, which is the medium for contaminant transport in the area. For these reasons, this site would not be significantly impacted by a Corps of Engineers project nor will it significantly impact upon a Corps of Engineers project on Absecon Inlet. The complete HTRW analysis can be found in Appendix A of the Main Report.

4.12 SOCIO-ECONOMIC RESOURCES

Absecon Island is comprised of four communities; Atlantic City, Longport, Margate, and Ventnor, all of which are located within Atlantic County's 565 square miles. Atlantic County is the 6th least populated county within New Jersey, with a total population of 224,327 year round residents in 1990, equalling only 2.5% of the state's permanent population. Although Atlantic County covers 565 square miles, approximately three-quarters of the residents live within five miles of the ocean. Early development along these beach front communities is responsible for the currently slow growth trend within the study area's boundaries. Despite the slow growth rate, over 85% of seasonal residents in Atlantic County are concentrated in the island communities of Atlantic City, Brigantine, Longport, Margate, Ventnor and the backbay communities of Absecon, Linwood, Northfield and Sommers Point.

These communities rely heavily on the tourist industry for their economic stability. Although South Jersey is largely responsible for supporting the "Garden State" image, 62.9% of Atlantic County residents depend on service and sale oriented companies, while only 0.42% of the work force is employed in farming, fishing, or forestry.

Within the county, Atlantic City is the most heavily developed community with a population of 40,199 year-round residents in 1990, and 3,347.71 people per square mile, accounting for 2/3 of the study area's population. Between 1980 and 1990 however, Atlantic City experienced a decline of 5.6%, lowering the population to 37,986. The population is expected to continue to decline into the year 2000, when it will rise to approximately 40,450.

New development has slowed over recent years. In 1991 only one new privately owned housing unit was authorized by building permits in comparison to the 39 units authorized in 1990. This is largely due to the lack of vacant land, as only 6% of the total property was vacant by the year 1993. Unlike the majority of the study area, Atlantic City is heavily commercialized, composing 76.8% of the tax base, with only 14.28% residential. Atlantic City's beaches are primarily lined with commercial buildings such as hotels, casinos, and shops, while Longport, Margate, and Ventnor remain mostly residential.

The casinos have helped make the Atlantic City boardwalk famous, while helping to attract a total of 3.2 million visitors in 1993 alone. Not only have the casinos helped the city bring in needed tourist related jobs, but they have also helped to rebuild the neighboring communities by forming an organization called the Casino Reinvestment Development Authority (CRDA). In conjunction with the CRDA, Atlantic City has planned a $42 million housing rehabilitation program, which began construction in 1993. The program will provide 198 housing units on a 15 acre track of land in the Inlet section of Atlantic City.

To the south of Atlantic City is Ventnor, a resort city with a boardwalk and approximately 1.5 square miles of public beach, which nearly 28,000 summer residents came to enjoy in 1993. Ventnor's population has also declined over the past decade by approximately 6%, to 11,005 in 1990. It is projected that the population will continue to decline by 5% until the year 2000, to a total of 10,418.

Because of the town's proximity to Atlantic City, Ventnor is also very highly developed, with a total of 5,135 residents per square mile. In 1991 there were only three building permits issued for single family units, compared to 27 permits authorized in 1989. The community is primarily residential, with only 2 industrial complexes and 141 commercial lots within the city's boundaries.

Bordering Ventnor to the south is Margate. Unlike Ventnor and Atlantic City, Margate is more of a residential community. Margate encompasses 1.41 square miles of land. Neither Margate nor Longport own boardwalks, however all of their beaches allow public access. The beach front is almost solely residential, with only a few commercial and public buildings.

Like all of the cities in the study area, Margate has primarily a service oriented labor force. Out of 4,563 civilian employees, 53% are service oriented with only 0.15% in the farming, fishing and forestry industry.

The last town in the study area is Longport, which lies between Margate and Great Egg Harbor Inlet. Longport is a small, quiet, residential community with older residents. The median age is 58.4, years and more than half of the residents are retired. There are no boardwalks or amusement parks to attract the younger crowd, however there are approximately 1.24 square miles of public access beaches, which bring in nearly 6,000 summer residents and 1,224 year round residents.

5.0 ENVIRONMENTAL CONSEQUENCES

5.1 COMPARATIVE EFFECTS OF ALTERNATIVES

The no action alternative will allow continuation of existing conditions, as well as the existing processes which currently modify those conditions. Consequently, the following discussion will focus on the impacts of the beach nourishment and bulkhead alternative, with impacts associated with the no action alternative discussed when appropriate.

5.2 TOPOGRAPHY AND SOILS

Under the no action alternative, erosion would continue and more beach would be lost. Without further engineering efforts, the existing bulkheads and erosion control measures would be rendered ineffective or breached as the beach profile becomes steeper and the wave energy becomes harsher.

The beach nourishment alternative would result in topography changes in the proposed Absecon Inlet borrow area. The dredging would increase the depth by approximately 12 to 15 feet in the borrow area. Based on the quantities of material required, all 345 acres of the borrow area will probably need to be utilized. The resulting cross-sectional configuration would be designed to approximate natural ridge slopes, and therefore promote free exchange of water with the overlying and adjacent waters. The excavation would also be designed to ensure that all of the bottom substrate would not be removed, and therefore the bottom would retain its existing substrate character. In addition, due to the dynamic location of the borrow area within the Inlet, it is anticipated that the sand source will be replenished fairly quickly. The intent of excavating a broad basin with depth, contours, and substrate consistent with the adjacent areas was to simulate the character of these nearby environments. It is not anticipated that the proposed excavation of material should adversely affect sand and gravel production.

Regarding the beach, the berm restoration would result in a berm 100 feet wide in Ventnor, Margate, and Longport, and 200 feet wide in Atlantic City. All areas would have a final berm elevation of +8.5 feet NGVD. A dune with a top elevation of +14 feet NGVD and a top width of 25 feet will be constructed in Ventnor, Margate, and Longport, while in Atlantic City the top elevation will be +16 feet NGVD. The grade of the foreshore and underwater slopes would essentially parallel the existing profile. The increase in beach elevation would effectively widen the beach. The net result would be a larger buffer against the erosion from storm events, and also an increase in usable beach in the project area.

Results from coastwide acoustic subbottom profiling and vibrocores indicate that three potential borrow areas exist for the Absecon Island area. Detailed information on these borrow areas can be found in section 3.5.1 of the FEIS and Borrow Area Selection section of the main report.

5.3 WATER QUALITY

The dredging associated with the beach nourishment alternative would result in short-term adverse impacts to water quality in the immediate vicinity of the dredging and beach nourishment operations. Dredging in the proposed borrow area will generate turbidity, resulting in sedimentation impacts within the immediate vicinity of the operations. Short-term increased turbidity can effect organisms in several ways. Primary production in phytoplankton and/or benthic algae may become inhibited from turbidity. Suspended particulate matter can clog gills and inhibit filter-feeding species. Reilly et.al. 1983 determined that high turbidity could inhibit recruitment by pelagic larval stocks. In addition, midwater nekton like finfish and mobile benthic invertebrates may migrate outside of the area where turbidity and deposition occur.

The amount of turbidity and its associated plume is mainly dependent on the grain size of the material. Generally, the larger the grain-size, the smaller the area of impact. The period of turbidity is also less with larger grain-sized materials. The proposed borrow location contains medium to fine sands, which are coarser grained than silts and clays. Turbidity resulting from the resuspension of these sediments is expected to be localized and temporary in nature. Utilization of a hydraulic dredge with a pipeline delivery system will help minimize the impact, however, some disturbance will occur.

Similar effects to water quality on aquatic organisms could likely be incurred from the deposition of borrow material on the beach. Increased turbidity resulting from the deposition of a slurry of sand will be temporary in nature and localized. This effect will not be significant as turbidity levels are naturally high in the high-energy surf zone. Organisms in the surf zone versus deep water areas will be less likely to suffer adverse effects from turbidity because they have already adapted to these conditions. Fine sediments sifted from the deposited material would be transported by waves and currents into the nearshore with varying environmental impacts from a few months to at least seven years (Hurme and Pullen, 1988). Parr et al, 1978 determined that fine materials were rapidly sorted out and transported offshore after beach deposition. In their study, the dredged material had a much higher silt content than the beach, however, all of the silt was removed within 5 months. The selection of borrow material from a high energy environment should minimize the fine particle content. Material taken from the proposed Absecon Island borrow area will have low quantities of silt, therefore, high levels of turbid waters after deposition should not persist.

The borrow material is not expected to be chemically contaminated. The use of beach nourishment quality sand from a high energy environment coupled with the absence of nearby dumping activities, industrial outfalls, or contaminated water infers the low probability that the borrow material would be contaminated by pollutants.

5.4 TERRESTRIAL ECOLOGY

5.4.1 Effects on Flora and Fauna of Upper Beach

Construction of the beach nourishment alternative would result in the initial placement of approximately 6.2 million cubic yards of sand on the beach, with subsequent periodic nourishments of approximately 1,666,000 cubic yards every 3 years for a project life of 50 years. This construction will greatly disturb the impacted beach area, however, impacts to terrestrial species are expected to be minor and temporary. The existing species inhabiting the beach are generally capable of surviving adverse conditions, and most are capable of migrating out of the impacted area. Therefore, impacts are not expected to be significant. It would be reasonable to expect recolonization from adjacent areas shortly after the end of construction, and a rapid return to pre-construction conditions.

5.5 AQUATIC ECOLOGY

5.5.1 Effects of Beachfill Placement on Benthos

The majority of the impacts of beachfill placement will be felt on organisms in the intertidal zone and nearshore zones. The nearshore and intertidal zone is highly dynamic, harsh, and is characterized by great variations in various abiotic factors. Fauna of the intertidal zone is highly mobile and responds to stress by displaying large diurnal, tidal, and seasonal fluctuations in population density (Reilly et al. 1983). Despite the resiliency of intertidal benthic fauna, the initial effect of beachfill deposition will be the smothering and mortality of existing benthic organisms within the shallow nearshore (littoral) zone. This will initially reduce species diversity and number of animals. Burial of less mobile species such as amphipods and polychaete worms would result in losses, however, densities and biomasses of these organisms are relatively low on beaches. Beach nourishment may also inhibit the return of adult intertidal organisms from their nearshore-offshore overwintering refuges, cause reductions in organism densities on adjacent unnourished beaches, and inhibit pelagic larval recruitment efforts. Parr et al.1978 notes that the nearshore community is highly resilient to this type of disturbance, however, the offshore community is more susceptible to damage by receiving high sediment loads from fines sorting-out from a beachfill. The ability of a nourished area to recover depends heavily on the grain size compatibilities of material pumped on the beach (Parr et al.,1978). Reilly et al. 1978 concludes that nourishment initially destroys existing macrofauna, however, recovery is usually rapid after pumping operation ceases. Recovery of the macrofaunal component may occur within one or two seasons if grain sizes are compatible with the natural beach sediments. However, the benthic community may be somewhat different from the original community. Hurme et. al. 1988 caution, "Macrofauna recover quickly because of short life cycles, high reproductive potential, and planktonic recruitment from unaffected areas. However, the recolonization community may differ considerably from the original community. Recolonization depends on the availability of larvae, suitable conditions for settlement, and mortality. Once established, it may be difficult for the original community species to displace the new colonizers." Benthic recovery on the beach/intertidal zone may become hampered by the three-year periodic nourishments. Based on the above mentioned studies, the benthic community may take 1-2 years to recover. With a three-year renourishment cycle, the benthic community may be in a higher than normal state of flux due to periodic disturbances from re-nourishment. It is conceivable that the benthic community may attain a recovered state for a period of 1-2 years before being disturbed again by a re-nourishment cycle.

Geomorphological studies on the sediments within the proposed borrow sites indicate that there will be relatively low levels of fine sediments placed on the Absecon Island beach. Parr et.al. 1978 recommend that to minimize biological impacts, the percentage of fine sediments (smaller than 125 micrometers) should be low to minimize siltation and consequent deposition offshore, which may create anoxic conditions in the sediment. The berm restoration would be conducted in a manner that approximates the existing beach profile. The approximate area of intertidal and shallow nearshore habitat lost resulting from the beachfill would be likewise created seaward. Therefore, no signigicant loss of intertidal or shallow nearshore habitat is expected.

5.5.2 Effects on Benthos at Borrow Sites

The primary ecological impact of dredging the sand borrow sites will be the complete removal of the existing benthic community through entrainment into the dredge. It is estimated that approximately 345 acres of benthic habitat will be impacted by dredging during the project. Dredging will primarily impact the benthic and epibenthic organisms. Mortality of these organisms will occur as they pass through the dredge device and/or as a result of being transplanted into an unsuitable habitat. A secondary disturbance would be the generation of turbidity and deposition of sediments on the benthic community adjacent to the dredging. Despite the initial effects of dredging on the benthic community, recolonization is anticipated to occur within one year. Saloman et al. 1982 determined that short-term effects of dredging lasted about one year resulting in minor sedimentological changes, and a small decline in diversity and abundance within the benthic community. The recovery of a borrow area is dependent upon abiotic factors such as the depth of the borrow pits, and the rate of sedimentation in the borrow pits following the dredging. Dredging a borrow pit can result in changes that affect circulation patterns resulting in pits where fine sediments can become deposited, which may lead to hypoxia or anoxia in the pit. Accumulations of fine sediment may also shift a benthic community from predominantly a filter-feeding community to a deposit-feeding community. It is important that for recovery, the bottom sediments are composed of the same grain sizes as the pre-dredge bottom. Cutler et al. (1982) investigated long-term effects of dredging on the benthic community and noted that faunal composition was different than the pre-dredge community, however, the difference was attributed more to normal seasonal and spatial variations. In this study, it was determined that there were no significant differences in the benthic communities and sediment parameters between borrow sites and surrounding areas. Periodic disturbances from maintenance of the project may favor the development of benthic communities composed primarily of colonizers. Assuming that the same location is dredged every three years, the secondary benthic community may be in a higher state of flux than the original community. This may, in effect, favor more r-selected (rapid reproduction, short life span) benthic species in the sand borrow impact area over the 50-year project life. In addition, benthic organism abundances may be lower than normal. However, this may not be the case if subsequent dredging cycles are conducted at different locations within the borrow area. This would allow disturbed areas from previous dredging disturbances to become recolonized.

Benthic investigations in and around the selected borrow sites reveal benthic communities that range between low and high infaunal abundance with low species diversity. Recolonization of the benthic community may occur within 1-2 years following dredging, however, the effects of the three year periodic project maintenance over a 50 year project life may have more profound adverse effects if conducted at the same locations. Hurme et al. (1988) recommend that borrow materials be obtained from broad, shallow pits in nearshore waters with actively shifting bottoms, which would allow for a sufficient surficial layer of similar sediments for recolonization. Measures that would minimize the effects of dredging in the borrow area include dredging in a manner as to avoid the creation of deep pits, alternating locations of periodic dredging, dredging during lowest biological activity, and the utilization of a hydraulic dredge with a pipeline delivery system to help minimize turbidity.

5.5.3 Effects of Groin Burial on Marine Biota

Groins, which represent artificial rocky intertidal habitat, will be subject to sand burial from beach nourishment. The landward ends of some of the groins would be permanently covered with sand. Once covered, the landward ends of the groins would not be available for fishermen to use nor to provide habitat for invertebrates, finfish, and shorebirds. Non-mobile organisms and intertidal dwellers would be affected by burial from the placement of sand. The fill placement over the groins is expected to re-establish sandy bottomed intertidal habitat.

5.5.4 Impacts on Fisheries

5.5.4.1 Shellfish

Sampling conducted by Versar, Inc. in October 1995 documented the current population of surf clams within the 3 proposed borrow areas. The borrow area proposed for the initial beachfill and nourishment cycles, Absecon Inlet borrow area, contains the lowest densities of surf clams. It is anticipated however, that the surf clams within this borrow area will be removed during dredging activities. Mortality of the clams will occur as they pass through the dredge device and/or as a result of being transplanted into an unsuitable habitat. A secondary disturbance would be the generation of turbidity.

In order to minimize impacts to surf clams within the project area, dredging activities will primarily take place within the Absecon Inlet borrow area for the initial construction, as well as the subsequent nourishment cycles. If, due to available sand quantities, it becomes necessary to utilize one of the other borrow areas for subsequent nourishment cycles, updated surveys will be done to determine current populations. Measures will be taken in Absecon Inlet, as well as the other borrow areas if necessary, to minimize impacts to the clams. Some of these measures may include the commercial harvest of clams prior to dredging and only disturbing a portion of the site. All measures will be fully coordinated with the appropriate Federal, state, and local agencies.

5.5.4.2 Finfish

With the exception of some small finfish, most bottom and pelagic fishes are highly mobile, and should be capable of avoiding entrainment into the dredging intake stream. It is anticipated that some finfish would avoid the turbidity plume while others may become attracted to the suspension of food materials in the water column. Little impact to fish eggs and larvae are expected because these life stages are widespread throughout the Middle Atlantic Bight, and not particularly concentrated in the borrow site or surf zone of the project area (Grosslein and Azarovitz, 1982).

The primary impact to fisheries will be felt from the disturbance of benthic and epibenthic communities. The loss of benthos and epibenthos entrained or smothered during the project will temporarily disrupt the food chain in the impact area. This effect is expected to be temporary as these areas become rapidly recolonized by pioneering benthic and epibenthic species.

5.6 THREATENED AND ENDANGERED SPECIES

The piping plover, which is State and Federally listed as threatened, is a frequent inhabitant of New Jersey's sandy beaches. Past nesting sites of this species in New Jersey have included the southern end of Brigantine, Ocean City, and several locations in Cape May. No known nesting sites have been identified within the study area on Absecon Island. Based on the high development and human disturbance, it is unlikely for piping plovers to nest within the project area. However, if a piping plover nest is discovered within the project area prior to the commencement of the initial beach nourishment and periodic maintenance activities, the Corps will contact the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife and the U.S. Fish and Wildlife Service to determine appropriate measures to protect the piping plovers from being disturbed. These measures may include establishing a buffer zone around the nest, and limiting construction to be conducted outside of the nesting period (1 April - 15 August).

From June through November, New Jersey's coastal waters may be inhabited by transient sea turtles, especially the loggerhead (Federally listed threatened) or the Kemp's ridley (Federally listed endangered). Sea turtles have been known to be adversely impacted during hopper dredging operations. Dredging encounters with sea turtles have been more prevalent along waters of the southern Atlantic and Gulf coasts, however, incidences of "taking" sea turtles have been increasing in waters of the middle Atlantic coast. Coordination with the National Marine Fisheries

Service (NMFS) in accordance with Section 7 of the Endangered Species Act has been undertaken on all Philadelphia District Corps of Engineers dredging projects that may have impacts to Federally threatened or endangered marine species. A Biological Assessment that discusses Philadelphia District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles has been prepared, and was formally submitted to the NMFS in accordance with Section 7 of the Endangered Species Act. It is anticipated that the NMFS will issue a Biological Opinion prior to preparation of the Final Environmental Impact Statement. Adherence to the findings of the Biological Opinion will insure compliance with Section 7 of the Endangered Species Act. In the interim, measures to reduce the likelihood of disturbing or taking of these species would be implemented through coordination with the NMFS. Recent projects that have utilized a hopper dredge between June and November have been required to place NMFS approved sea turtle observers on the dredge to monitor for sea turtles during dredging. Observers inspect the hopper, skimmer, and draghead after each load looking for signs of interaction with endangered or threatened species. Other measures that have been taken to reduce the impact to sea turtles include the use of rigid dragarm deflectors and pre-dredging trawling.

5.7 IMPACTS ON CULTURAL RESOURCES

5.7.1 Project Impact Areas for Cultural Resource Review

Proposed project construction has the potential to impact cultural resources in four areas. These are the existing beach and near-shore sand placement areas, inlet frontage, and offshore borrow areas. In the beach and near-shore sand placement areas, potential impacts to cultural resources could be associated with the placement and compaction of sand during berm and dune construction. Impacts in the inlet frontage area could occur during bulkhead and revetment construction. Dredging activities in offshore borrow areas could impact submerged historic properties.

5.7.2 Shoreline and Near-shore Sand Placement Areas

On the basis of the current project plan, the Corps is of the opinion that sand placement within shoreline and near-shore project areas will have no effect on significant cultural resources. These areas are located in a highly unstable and shifting coastal environment, where the likelihood for intact and undisturbed cultural resources is considered extremely minimal. No archaeological sites were identified during documentary and pedestrian shoreline surveys (Cox and Hunter, 1995). The shoreline survey did identify two historic entertainment piers that are potentially eligible for listing in the National

Register of Historic Places - the Steeplechase Pier and the Garden Pier. Sand placement will have no effect on these two properties. A remote sensing survey was not conducted in the near-shore project area due to unsafe conditions in a very high energy, tidal surf zone. Properties in the Absecon Island area currently listed on the National Register of Historic Places are located outside of the project area.

5.7.3 Inlet Frontage Area

The proposed plan includes the construction of a timber sheet-pile bulkhead and quarry stone revetment along the south side on Absecon Inlet. Bulkhead construction will follow a previously disturbed older bulkhead alignment adjacent to Maine Avenue. A quarry stone revetment will be built next to the new bulkhead and will extend out into the inlet in an area that has been previously modified and dredged on numerous occasions. For these reasons, a cultural resources pedestrian and remote sensing survey was not conducted in these project areas. Alterations to the natural topography is severe. The District anticipates that no significant cultural resources will be affected in these project locations.

5.7.4 Offshore Borrow Areas

Remote sensing investigations were conducted in project borrow areas (Cox and Hunter 1995). No targets resembling potential shipwrecks were recorded in the Offshore and Longport borrow areas. Sand dredging will have no effect on significant cultural resources in these project locations. Seven underwater targets were identified in the Absecon Inlet Borrow Area. Underwater ground-truthing and re-analysis of previously recorded and newly acquired remote sensing data suggests that five of these targets are potentially significant shipwreck sites (Cox 1995). Proposed sand borrowing activities will adversely impact three of these target locations, which may represent significant cultural resources. Therefore, in order to eliminate construction impacts at these locations, the Philadelphia District proposes to completely avoid these three remote sensing targets during sand borrowing operations by delineating at least a 200 foot buffer around each target.

5.7.5 Section 106 Coordination

The draft report of the remote sensing investigation, entitled "A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey (Cox and Hunter 1995) and an executive summary entitled "A Phase 1 and 2 Submerged and Shoreline Cultural Resources Investigation, Brigantine Inlet to Hereford Inlet, Atlantic and Cape May Counties, New Jersey" (Cox 1995) was submitted to the New Jersey State Historic Preservation Office (NJSHPO) for Section 106 review and comment on December 4, 1995 (see Pertinent Correspondence Appendix). The Philadelphia District does not anticipate any impacts on significant cultural resources resulting from berm, dune, bulkhead and revetment construction along shoreline and inlet areas as proposed in the feasibility study. Potentially significant submerged sites identified in the Absecon Inlet Borrow Area will be avoided by a 200 foot buffer around each target and will not be impacted by proposed dredging. The NJSHPO concurred with the District's finding of "No Effect" in a letter dated January 19, 1996 (see Pertinent Correspondence Appendix).

5.8 IMPACTS ON NOISE AND AIR QUALITY

Minor short-term impacts to air quality and noise levels would result from the construction phases of the beach nourishment alternative. Dredging activities and grading equipment use would produce noise levels in the 70 to 90 dBA (50 feet from the source) range, but these would be restricted to the beach area. These noises would be masked by the high background levels of the surf or dissipated by distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. In the case of equipment use associated with the periodic nourishment efforts, conducting the work in the off-season would further minimize the impact.

Noise and air quality impacts would be restricted to site construction preparation (generally beginning two weeks prior to dredging) and the actual dredging and placement operation. Noise is limited to the utilization of heavy equipment such as bulldozers to manipulate the material during placement. Additional noise may be caused by a pumpout station, if necessary. Depending on future circumstances, the construction may be conducted overnight to meet construction schedules. Air quality impacts would similarly be limited to emissions from the heavy equipment and pumpout station (if used). No long-term significant impacts to the local air quality are anticipated.

Air quality impacts would similarly be limited to emissions from the heavy equipment used during construction. Pollutant emissions discharged from heavy equipment such as dredges and dozers are regulated by the EPA on the engine manufacturers. Since dredging operations would be conducted in a "moderate" non-attainment area for ozone, equipment operations would not have any long-term adverse effects on the attainment criteria in Atlantic County. The Environmental Protection Agency Region II had reviewed the Draft EIS, and had no adverse comments relative to air quality impacts pursuant to Section 309 of the Clean Air Act. A statement of conformity with the State Implementation Plan is provided in Section 9.0 of this FEIS.

5.9 IMPACTS ON SOCIO-ECONOMICS

The no action alternative would allow the beach to continue to erode, and this would increase the risk of damage to private property from flooding or direct wave action as the protective beach decreased in size. Property values would also fall as this risk became more and more perceived by the market. Recreational opportunities would also decrease with the size of the beach. This would be translated into lost tourism revenue which would have a secondary effect on employment.

New Jersey beaches and casinos are consistently one of the main travel destinations in New Jersey, and account for a large portion of the State's visitations and revenue. It is expected that local and State efforts to attract visitation and expand their associated facilities will continue. The New Jersey beaches and casinos play an extremely significant role in the well being of New Jersey's tourism industry, and in New Jersey's overall economy.

Under the beach nourishment alternative, the beach berm created by the placement of suitable material and periodic nourishment would permit the accommodation of both present and expected future demands for recreational beach area along Absecon Island. This influx of seasonal population is reflected by a greater demand for social services such as housing, transportation, health, safety, and sanitation facilities. As the demand for recreation gradually increases, it is expected that State and local efforts would be made to satisfy these needs. Because of this, noise and air quality levels would similarly degrade through personal activity and auto utilization. They will not however, become a significant problem.

Various indicators of the presence and/or level of Corps activity in beachfront communities generally have no statistically significant relation to development in those areas. Thus, the statistical evidence indicates that the effect of the Corps on induced development is, at most, insignificant, compared to the general forces of economic growth which are stimulating development in these areas, many of which are induced through other municipal infrastructure developments such as roads, wastewater treatment facilities, etc. (U.S. Army Corps of Engineers, 1995).

5.10 RECREATION

The proposed project as a secondary benefit, may improve opportunities for recreational beach use. Recreational shore and surf fishing will be temporarily affected by the project, since the public and fishermen will not be permitted to enter the actual work segments. However, since the project will be constructed in sections, only those sections actually under construction will be closed to the public. Impacts to shore and surf fishing access will be localized and relatively short-lived. A minor impact on recreational fishing will result from covering the existing groins with sand.

5.11 AESTHETICS

Beach nourishment is a more natural and soft structural solution to reducing storm damages on Absecon Island. With the exception of short-term impacts during construction, overall aesthetics of the beach would be improved as a result. A natural-looking beach and dune would be more aesthetically pleasing and attractive to residents and tourists. However, despite the visual benefits the beach nourishment alternative would provide, a restored dune may inhibit ocean views in some project impact areas.

The boardwalk elevations on Absecon Island range from 10.5 to 15 feet NGVD. At the lower elevations, views of the ocean may be impacted. However, of the 3.4 miles of boardwalk in Atlantic City, only seven percent is below 11 feet NGVD. Therefore, in these areas, the possibility exists for some aesthetic impacts in terms of the accessability of wave and ocean views. Currently there are some areas within Absecon Island that have limited views of the ocean. This is due to the fact that dune repairs/restoration have been made in some areas which have increased the height of the dunes. This, combined with the narrow width of the beach, leaves the waves breaking close to the toe of the dunes and hampering the visual aesthetics. If the dunes for the proposed project were built on the current beach, aesthetic impacts would also exist due to the fact that currently the waves break very close to the toe of the dune in many areas of the project. Once the proposed beachfill is in place however, the area where the waves break will be much further from shore, therefore making the waves easier to see from the boardwalk, and minimizing negative aesthetic impacts.

5.12 UNAVIODABLE ADVERSE IMPACTS

The long-term adverse impact of the no action alternative would not be to the natural environment but to the regional economic environment. Tourism and utilization would decrease as beach loss continues. As the risk of storm damage increases, property values would decrease. Actual storm damage and higher insurance premiums would erode business profits.

The long-term adverse impact of the beach nourishment alternative would be the decreased benthic community standing stocks, which would be affected during each dredging operation.

5.13 SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

The no action alternative does not involve short-term uses but would affect the long-term economy of the project area as indicated in Section 5.9. On the other hand, the beach nourishment alternative would enhance the economy by storm damage reduction as well as by providing additional recreational area.

5.14 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The no action alternative does not involve a commitment of resources. The beach nourishment alternative would involve the utilization of time and fossil fuels which are irreversible and irretrievable. Impacts to the benthic community would not be irreversible as benthic communities would redevelop with cessation of all dredging activity.

5.15 CUMULATIVE EFFECTS

Cumulative Impact as defined in CEQ regulations is the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Projects of this nature using beach nourishment from offshore borrow sites are becoming increasingly common in coastal areas as areas of high development become susceptible to the erosive forces present. Numerous beach nourishment projects have been conducted along the Atlantic Coast since the 1950's by local, state and Federal agencies, as well as private interests. Depending on circumstances such as the methods being utilized to alleviate the coastal erosion and ensuing storm damages and the existing ecological and socio-economic conditions, it is difficult to gauge the net cumulative effects of these actions. The scientific literature generally supports that beach nourishment projects, if planned properly, have short-term and minor ecological effects, however, we are not aware of any studies that consider regional or national cumulative impacts of these projects on resources of concern. It is our position that since this project was designed to minimize adverse environmental effects of all types, this project should not culminate in adverse cumulative impacts on ecological and socio-economic resources, or if it does, to the minimum extent possible.

5.16 MITIGATION MEASURES

Mitigation measures are utilized to minimize or mitigate for project impacts to environmental resources within the project area. The appropriate application of mitigation is to formulate a project that avoids or minimizes adverse impacts first, and compensates for impacts only as a final alternative. Several measures can be adopted to avoid or minimize project impacts on effected resources such as: benthic resources, fisheries, endangered species, cultural resources, recreation, and noise.

Mitigation measures are either institutional in that environmental mitigation is inherent in project alternative selection, or as measures incorporated into the construction and operation and maintenance of the project. Several institutional measures have already been adopted to minimize the impacts on these resources. These measures include the selection of the beach nourishment alternative. This alternative offers a more naturalistic and softer approach for storm damage reduction. Selection of this alternative is based on its relatively low ecological impacts and its cost effectiveness. Another institutional measure is the utilization of offshore sand borrow areas. These areas are characterized by high energy and shifting sands resulting in a benthic community of lower abundance and diversity as compared to more stable benthic environments. Therefore, biological impacts are expected to be lower. Another measure is the selected use of suitable sand grain sizes for beach nourishment. The selection of borrow areas is based on compatibility studies for sand grain sizes. The selection of coarser beach nourishment quality material will minimize impacts on water quality at the dredging site and discharge (placement) site.

As discussed in the preceding paragraphs, the beach nourishment alternative does contain unavoidable impacts to several environmental resources of concern. These impacts can be minimized by implementing several measures during construction, and operation and maintenance of the project. Mitigation measures recommended for construction, and operation and maintenance of the project involve minimizing impacts to: benthic resources, fisheries, endangered species, recreation, noise and cultural resources. The following measures are recommended, however, their implementation is dependent upon the circumstances that may be encountered at the time of project construction or periodic maintenance.

5.16.1 Benthic Resources

The majority of unavoidable impacts are likely to be incurred on the benthic communities within the project area. Measures to minimize the effects of dredging in the borrow area will include dredging in a manner as to avoid the creation of deep pits, using only Absecon Inlet borrow area for the initial construction, using primarily Absecon Inlet for nourishment cycles as long as possible, alternating locations of periodic dredging, conducting dredging during months of lowest biological activity (when possible), and the utilization of a pipeline delivery system to help minimize turbidity. Implementation of a benthic monitoring program concurrent with periodic maintenance activities would document project impacts and aid in avoiding impacts to sensitive areas during the periodic maintenance activities.

5.16.2 Fisheries

Adverse impacts to the surf clam population may be minimized by trying to use only one borrow area (Absecon Inlet) for the initial beachfill and subsequent nourishment for as long as possible. This borrow area had the lowest numbers of surf clams and due to its location is not easily accessable to commercial clamming dredges. If it becomes necessary to utilize one of the other borrow areas for subsequent nourishment cycles, updated surveys will be done to determine current populations. If viable populations still exist within the proposed borrow areas, measures will be taken in order to minimize impacts to the clams. Some of these measures may include the commercial harvest of clams prior to dredging and only disturbing a portion of the site. All measures will be fully coordinated with the appropriate Federal, state, and local agencies.

5.16.3 Threatened and Endangered Species

Based on coordination with appropriate resource agencies and the high development in the project impact site, it is unlikely for piping plovers to nest within the project area. However, if a piping plover nest is discovered within the project area prior to the commencement of the initial beach nourishment and periodic maintenance activities, the Corps will contact the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife and the U.S. Fish and Wildlife Service to determine appropriate measures to protect the piping plovers from being disturbed. These measures may include establishing a buffer zone around the nest, and limiting construction in these areas to periods outside of the nesting season (1 April - 15 August).

Depending on the timing of the dredging and the type of dredge to be used, it may be necessary to implement mitigative measures to avoid adversely impacting threatened or endangered sea turtles. Measures to avoid or minimize impacts to these species may include but not be limited to utilizing NMFS approved turtle monitors, utilizing specially modified hopper dredges, and use of trawlers that can intercept and transport turtles away from the dredging impact area. It may not be necessary to implement these measures if dredging is conducted within the winter months when turtle activity is lowest in this area. These measures would be implemented based on the findings of the forthcoming Biological Opinion to be issued by NMFS.

5.16.4 Recreation

Beachfill operations typically occur within isolated segments, subsequently moving as the work progresses. As each work segment is completed, it can be opened for recreational use. This would allow access for recreation in all areas outside of the segment under construction.

5.16.5 Air Quality and Noise

Air quality and noise impacts can be reduced by utilizing heavy machinery fitted with approved muffling apparatus that reduces noise, vibration, and emissions.

5.16.6 Cultural Resources

The identification of five small magnetic targets within the proposed Absecon Inlet sand borrow area exhibiting shipwreck characteristics will be avoided during project construction. This will be accomplished by delineating at least a 200 foot buffer around each target.

6.0 LIST OF PREPARERS

6.1 INDIVIDUAL CONTRIBUTORS AND THEIR RESPONSIBILITIES

The following individuals were primarily responsible for the preparation of this Environmental Impact Statement.

Individual	Responsibility
Jerry J. Pasquale B.S. Biology M.S. Ecology 13 years EA and EIS preparation and review experience	Technical review
Beth Brandreth B.S. Marine Biology 4 years EA and EIS preparation and review experience	Scoping, EIS preparation and coordination
Mike Swanda B.A. Archaeology M.A. Archaeology 20 years cultural resource experience	Scoping, EIS preparation (Cultural Resources)
Doug Gaffney B.S. Marine Engineering M.S. Applied Ocean Science 6 years project management experience	Study Manager
Monica Chasten B.S. Civil Engineering M.S. Civil Engineering 10 years coastal engineering experience	Hydraulic/Coastal Engineering
Sharon Grayson B.A. Economics 4 years economic analysis experience	Economic analysis
Gizella Geissele B.S. Civil Engineering 4 years project design experience	Civil Works Design Engineering

Brian Murtaugh B.S. Civil Engineering M.S. Civil Engineering 5 years geotechnical engineering experience	Borrow Area & Beachfill Analysis
Sterling Johnson B.S. Materials Science and Engineering 5 years cost engineering experience	Project Cost estimation
Megan Coll B.S. Civil Engineering 5 years engineering experience	Civil Works Project Manager

6.2 Studies Conducted for or Reported in this Draft Environmental Impact Statement

6.2.1 Benthic Evaluation

"Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey: Benthic Animal Assessment of Potential Borrow Source" (Battelle Ocean Sciences, 1995) in Appendix A.

"Evaluation of Benthic Macrofaunal Resources at Potential Sand Borrow Sources: Brigantine Inlet to Great Egg Harbor Inlet, Atlantic County, New Jersey" Versar, Inc, 1996)

6.2.2 Cultural Resources

"A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey (Draft)". (Hunter Research, 1995) in Appendix A.

"A Phase 1 and 2 Submerged and Shoreline Resources Investigation, Brigantine Inlet to Hereford Inlet, Atlantic and Cape May Counties, New Jersey (Executive Summary)". (Hunter Research, 1995) in Appendix A.

7.0 PUBLIC INVOLVEMENT

Coordination for this project was done with Federal, State and local resource agencies. Agencies notified of this study included the U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS), New Jersey Department of Environmental Protection (NJDEP), and New Jersey State Historic Preservation Office. Information in this document was generated based on comments and concerns of the interested public.

Two Planning Aid Reports prepared by the USFWS are provided in Appendix C of the main report. An official section 2(b) Fish and Wildlife Coordination Act Report was prepared by the USFWS after public circulation of the Draft Environmental Impact Statement and is provided in the comment/response section. This report provides official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act. Comments received from Federal, State, and local government agencies along with various private organizations and individuals on the DEIS are presented in the comment/response appendix of this report.

A copy of the DEIS along with this FEIS were provided to the following individuals/agencies for review:

Mr. Richard Sanderson
Office of Federal Activities
EIS Filing Section (2252)
U.S. Environmental Protection Agency
Arial Rios Bldg (South Oval Lobby)
Mail Code 2251-A
1200 Pennsylvania Avenue, NW
Washington, DC 20044

Donna S. Wieting, Acting Director
Ecology & Conservation Office
National Oceanic & Atmospheric Admin.
Commerce Building, Room 5813
Washington, DC 20230

Mr. Robert Stern, Director
Office of Environmental Compliance
Department of Energy, Room 3G092
1000 Independence Avenue, SW
Washington, DC 20585

Mr. Larry Zensinger, Chief
Hazard Mitigation Branch
Public Assistance Division
Federal Emergency Management Admin.
500 C. Street, SW, Room 714
Washington, DC 20472

Mr. Robert Bush, Executive Director
Advisory Council on Historic
Preservation
The Old Post Office Building, Rm 809
1100 Pennsylvania Avenue, NW
Washington, DC 20004

Honorable Frank R. Lautenberg
United States Senator
208 White Horse Pike
Suites 18-19, Barrington Commons
Barrington, New Jersey 08007-1322

Congressman Frank A. LoBiondo
Suite 103
5914 Main Street,
Mays Landing, New Jersey 08330
ATTN: Gabriel Donio

Senator Frank R. Lautenberg
United States Senate
506 Hart Senate Office Building
Washington, D.C. 20510-3002

Senator Bill Bradley
United States Senate
731 Hart Senate Office Building
Washington, D.C. 20510

Atlantic County
Office of Policy, Planning & Economic Development
1333 Atlantic Avenue
Atlantic City, New Jersey 08401
ATTN: Lauren H. Moore, Jr., Director

Atlantic City Beach Control Headquarters
Room 108 City Hall
Atlantic City, New Jersey 08401
ATTN: Robert Levy, Superintendant and Chief

341

Mr. Roy E. Denmark, Jr.
NEPA Review Coordinator
U.S. EPA Region III
3EP30
841 Chestnut Building
Philadelphia, PA 19107

Mr. Roger V. Amato
Minerals Management Service
INTERMAR
381 Elden St.
Herndon, VA 22070-4817

Mr. Michael Stomackin
Environmental Officer
U.S. Dept. of Housing & Urban Development
60 Park Place
Newark, NJ 07102

Mr. Thomas Schenarts
Area Director
State and Private Forestry
U.S. Forest Service
370 Reed Road
Broomall, PA 19008

Ms. Rita Calvan
Regional Director
Federal Emergency Management Admin.
Region III, Liberty Square Building
105 South 7th Street
Philadelphia, PA 19106

Mr. Fred Schmidt
Documents Librarian
Colorado State University
Fort Collins, CO 80523

Dr. Willie Taylor, Director
Office of Environmental Policy & Compliance
U.S. Department of the Interior
1849 C Street, NW
Room 2340
Washington, DC 20240

Mr. Michael Thompson (CENAN-PL-F)
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278-0090

Mr. Clifford Day
U.S. Fish and Wildlife Service
927 North Main Street (Building D)
Pleasantville, New Jersey 08232

Mr. Stanley W. Gorski
Assistant Coordinator, Habitat Program
National Marine Fisheries Service
Habitat & Protected Resources Division
Sandy Hook Laboratory
Highlands, New Jersey 07732

Mr. Robert Hargrove
EPA Region II
26 Federal Plaza

Ventnor City
Office of Emergency Management
6201 Atlantic Avenue
Ventnor, New Jersey 08406
ATTN: Bill Melfi, Coordinator

Margate City
1 South Washington Avenue
Margate, New Jersey 08402
ATTN: Bill Ross, Mayor

Borough of Longport
2305 Atlantic Avenue
Longport, New Jersey 08403
ATTN: Willioam A. Fiori, Mayor

Mr. Mark Fedorowycz
New Jersey Department of Environmental Protection
Land Use Regulatory Program
CN 401, 501 East State Street
Trenton, New Jersey 08625-0401

Mr. Bernard J. Moore, Administrator
Natural and Historic Resources
Engineering and Construction
1510 Hooper Avenue
Toms River, New Jersey 08753

Mr. Roy Wagner, Regional Design Engineer
Region IV
NJ Department of Transportation
CN 600, 1035 Parkway Avenue
Trenton, New Jersey 08625

Mr. James Hall
Assist. Commissioner for Natural & Historic Resources
NJ Department of Environmental Protection
CN 404, Station Plaza 5
501 East State Street, Floor 3
Trenton, New Jersey 08625-0404

Director, Office of Envir. Policy and Compliance
Department of the Interior
Main Interior Building, MS 2340
1849 C Street, NW
Washington, DC 20240

Mr. Paul Cromwell
Department of Health and Human Services
Room 531H Humphrey Building
200 Independence Avenue, SW
Washington, DC 20585

Ms. Debra Borie-Holtz, State Director of Farm Services
Mastoris Professional Plaza
163 Route 130
Building 2, Suite E, Second Floor
Bordentown, NJ 08505

Mr. Joseph Branco
State Conservationist
U.S. Department of Agriculture
1370 Hamilton Street
Somerset, New Jersey 08873

Commander (DPL)
Third Coast Guard Distirct

New York, New York 10278-0090

Mr. Larry Schmidt
NJ Department of Environmental Protection
Office of Programs Coordination
CN 418
Trenton, New Jersey 08625-0418

Ms. Dorothy Guzzo, Administrator
New Jersey Historic Preservation Office
NJ Department of Environmental Protection
CN 404
Trenton, New Jersey 08625

Mr. John R. Weingart, Director
Division of Coastal Resources
NJ Department of Environmental Protection
CN 401
Trenton, New Jersey 08625

Mr. George P. Howard, Director
Division of Fish, Game and Wildlife
NJ Department of Environmental Protection
CN 400
Trenton, New Jersey 08625-0400

Mr. Andrew Jaskolka
State Review Process
Division of Community Resources
CN 814
Trenton, New Jersey 08625-0814

Mr. Eric Ellefsen
Weeks Marine
901 Beach Street
Camden, NJ 08102

Ms. Kathy Ryalls
Great Lakes Dredge and Dock Co.
2122 York Road
Oakbrook, IL 60521

Governors Island

New York, New York 10004

Mr. John Kessler
Division Administrator
Federal Highway Administration
25 Scotch Road
Trenton, New Jersey 08628

Mr. Jason Smith
FX Browne Inc.
220 South Broad Street
Lansdale, PA 19446

Mr. Don Roder
32 9th Avenue
Haddon Heights, New Jersey 08035

Mr. Alan Dupont
32 9th Avenue
Haddon Heights, New Jersey 08035

Mr. Griff Evans
303 Allegheny Avenue
Towson, MD 21204

Mr. Steve Weisburg
Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045-1934

Mr. Douglas Kibble
RMC Environmental Services, Inc.
3450 Schuylkill Road
Spring City, PA 19475

8.0 EVALUATION OF 404(b)(1) GUIDELINES

I. PROJECT DESCRIPTION

A. Location

The proposed project site includes the communities of Margate, Longport, Atlantic City, and Ventnor, on Absecon Island, Atlantic County, New Jersey. In addition to these communities, the specific areas involved are the three borrow areas found in Absecon Inlet, offshore of Absecon Inlet, and in Great Egg Harbor Inlet.

B. General Description

The proposed project involves reducing potential storm damages along Absecon Island, New Jersey by placement of dredged material (sand) from the Absecon Inlet borrow area on the beachfront in the form of a berm 200 feet wide with a top elevation of +8.5 feet NGVD29 in Atlantic City, and a 100 foot wide berm with a top elevation of +8.5 feet NGVD29 in Ventnor, Margate, and Longport. In Margate, Ventnor, and Longport, dunes will also be constructed to a top elevation of +14 feet NGVD29, with a 25 foot top width, and side slopes of 1V:5H. The Atlantic City dune will have a top elevation of +16 feet NGVD29, top width of 25 feet, and side slopes of 1V:1H. The dunes are proposed to be planted with 91 acres of dune grass. The dunes will also contain 63,675 linear feet of sand fence, as well as pedestrian and vehicular access ramps.

The proposed project also includes the construction of two timber sheet-pile bulkheads along the Absecon Inlet frontage. The bulkheads would tie into the existing bulkhead along Maine Avenue. The bulkheads would be constructed to a top elevation of +14 feet NGVD29, with pile anchors and tie-backs. A revetment of 3-5 ton rough quarrystone will be constructed to an elevation of +5 feet NGVD29 on the seaward side of the bulkhead.

C. Authority and Purpose

The authority for the proposed project is the resolution of the Committee on Public Works and Transportation of the United States House of Representatives, and the Committee on Environment and Public Words of the United States Senate, dated December 1987.

The Senate resolution adopted by the Committee on Environment and Pubic Works on December 17, 1987 states:

"That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hearby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response".

The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

> "That the Board of Engineers for Rivers and Harbors is hearby requested to review existing reports for the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, the development of recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response which is engineeringly, economically, and environmentally feasible".

The purpose of the project is to reduce storm damages to the beaches and oceanfront structures along Absecon Island, Atlantic County, New Jersey.

D. General Description of Dredged or Fill Material

1. The proposed dredged material is medium to fine sand with little or no gravel present. Clay, silt, and organic content are low with neutral pH and low fertility. This material has been trapped by a combination of tidal and littoral forces and has been exposed to a high energy circulation regime.

2. The quantity required is estimated to be approximately 6.2 million cubic yards initially, with approximately 1,666,000 cubic yards every 3 years comprising periodic nourishment over a 50-year project life.

3. Three borrow areas were proposed as sources of the borrow material for this project. One area is located within Absecon Inlet and covers approximately 345 acres. The second area is located offshore, slightly southeast of the Inlet and is approximately 218 acres. The third area is located within Great Egg Harbor Inlet, covering approximately 190 acres. The total acreage available within these sites is 753 acreas. It is proposed that all material needed for the initial beach fill will be obtained from the Absecon Inlet borrow area. Depending on the rate of sedimentation in the borrow area, this will also be the first choice for subsequent nourishment activities.

E. Description of the Proposed Discharge Site

1. The proposed location is depicted in Figures 2 and 3 of the FEIS.

2. The proposed discharge site is comprised of an eroding berm, with a minimum design width of 200 feet in Atlantic City and 100 feet in Ventnor, Margate, and Longport.

3. The proposed discharge site is unconfined with placement to occur on a shoreline area.

4. The type of habitat present at the proposed location is a coastal intertidal and nearshore habitat.

5. Berm and dune restoration will be accomplished by beach nourishment. This plan will require approximately 6.2 million cubic yards of sand for initial beachfill placement, with approximately 1,666,000 cubic yards for periodic re-nourishment every 3 years over a 50 year

project life. The proposed plan includes approximately 7 miles of beachfill extending from Absecon Inlet to Great Egg Harbor Inlet. The proposed beach nourishment will result in a 200 foot wide berm with a top elevation of +8.5 feet NGVD29 in Atlantic City, and a 100 foot wide berm with a top elevation of +8.5 feet NGVD29 in Ventnor, Margate, and Longport. The beachfill will be transitioned from a 200 foot berm to a 100 foot berm between Atlantic City and Ventnor for a distance of 1000 feet. In Ventnor, Margate, and Longport, dunes will also be constructed to a top elevation of +14 feet NGVD29, with a 25 foot top width, and side slopes of 1V:5H. In Atlantic City, the dune will have a top elevtion of +16 feet NGVD29, a 25 foot top width, and side slopes of 1V:5H.

F. Description of Disposal Method

A hydraulic dredge or hopper dredge would be used to excavate the borrow material from the borrow area(s). The material would be transported using a pipeline delivery system to the beachfill placement site. Subsequently, final grading would be accomplished using standard construction equipment.

II. FACTUAL DETERMINATION

A. Physical Substrate Determinations

1. The final proposed elevation of the beach substrate after fill placement would be +8.5 feet NGVD29 at the top of the berm. The proposed profile would have a foreshore slope of 30H:1V and an underwater slope that parallels the existing bottom to the depth of closure.

2. The sediment type involved would be sand.

3. The planned construction would establish a construction template which is higher than the final intended design template or profile. It is expected that compaction and erosion would be the primary processes resulting in the change to the design template. Also, the loss of fine grain material into the water column would occur during the initial settlement.

4. The proposed construction would result in removal of the benthic community from the borrow area, and burial of the existing beach and nearshore communities when this material is put in place during berm construction.

5. Other effects would include a temporary increase in suspended sediment load and a change in the beach profile, particularly in reference to elevation.

6. Actions taken to minimize impacts include selection of fill material that is similar in nature to the pre-existing substrate. Also, standard construction practices to minimize turbidity and erosion would be employed.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Water. Consider effects on:

   a. Salinity - No effect.
   b. Water chemistry - No significant effect.
   c. Clarity - Minor short-term increase in turbidity during construction.
   d. Color - No effect.
   e. Odor - No effect.
   f. Taste - No effect.
   g. Dissolved gas levels - No significant effect.
   h. Nutrients - Minor effect.
   i. Eutrophication - No effect.
   j. Others as appropriate - None.

2. Current patterns and circulation

   a. Current patterns and flow - Circulation would only be impacted by the proposed work in the immediate vicinity of the borrow area, and in the beach zone where the existing circulation pattern would be offset seaward the width of the beach nourishment.

   b. Velocity - No effects on tidal velocity and longshore current velocity regimes.

   c. Stratification - Thermal stratification occurs beyond the mixing region created by the surf zone. There is a potential for both winter and summer stratification. The normal pattern should continue post construction of the proposed project.

   d. Hydrologic regime - The regime is largely marine and oceanic. This will remain the case following construction of the proposed project.

3. Normal water level fluctuations - The tides are semidiurnal with a mean tide range of 4.1 feet and a spring tide range of 5.0 feet in the ocean. Construction of the proposed work would not affect the tidal regime.

4. Salinity gradients - There should be no significant effect on the existing salinity gradients.

5. Actions that will be taken to minimize impacts- None are required: however, the borrow area would be excavated in a manner to approximate natural ridge slopes to ensure normal water exchange and circulation. Utilization of sand from a clean, high energy environment and its excavation with a hydraulic dredge would also minimize water chemistry impacts.

C. <u>Suspended Particulate/Turbidity Determinations</u>

1. Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site and Borrow Site - There would be a short-term elevation of suspended particulate concentrations during construction phases in the immediate vicinity of the dredging and the discharge. Elevated levels of particulate concentrations at the discharge locations may also result from "washout" after beachfill is placed.

2. Effects (degree and duration) on Chemical and Physical Properties of the Water Column -

   a. Light penetration - Short-term, limited reductions would be expected at the borrow and disposal sites from dredge activity and berm washout, respectively.

   b. Dissolved oxygen - There is a potential for a decrease in dissolved oxygen levels but the anticipated low levels of organics in the borrow material should not generate a high, if any, oxygen demand.

   c. Toxic metals and organics - Because the borrow material originates from a clean, high energy environment, and because it is essentially all medium to fine sand, no toxic metals or organics are anticipated.

   d. Pathogens - Pathogenic organisms are not known or expected to be a problem in the borrow or disposal area.

   e. Aesthetics - Construction activities and the initial construction template associated with the fill site would result in a minor, short-term degradation of aesthetics.

3. Effects on Biota

    a. Primary production, photosynthesis - Minor, short-term effects related to turbidity.

    b. Suspension/filter feeders - Minor, short-term effects related to suspended particulates outside the immediate deposition zone. Sessile organisms would be subject to burial if within the deposition area.

    c. Sight feeders - Minor, short-term effects related to turbidity.

4. Actions taken to minimize impacts include the selection of clean sand with a small fine grain component and a low organic content. Standard construction practices would also be employed to minimize turbidity and erosion.

D. <u>Contaminant Determinations</u>

The discharge material is not expected to introduce, relocate, or increase contaminant levels at either the borrow or placement sites. This is assumed based on the characteristics of the sediment, the proximity of the borrow site to sources of contamination, the area's hydrodynamic regime, and existing water quality.

E. <u>Aquatic Ecosystem and Organism Determinations</u>

1. Effects on Plankton - The effects on plankton should be minor and mostly related to light level reduction due to turbidity. Significant dissolved oxygen level reductions are not anticipated.

2. Effects on Benthos - Although there is a major disruption of the benthic community in the borrow area when the fill material is excavated, the 404(b)(1) analysis focuses on the disposal area effects. Here the disruption is significant as the entire community is subject to burial or displacement; however, the actual biomass of organisms impacted is far less due to the harsher environmental conditions present on the beach and in the surf zone. The loss is somewhat offset by the expected rapid opportunistic recolonization from adjacent areas that would occur following cessation of construction activities. Recolonization is expected to occur in the disposal (beachfill placement) area through horizontal and in some cases vertical migrations of benthos.

3. Effects on Nekton - Only a temporary displacement is expected as the nekton would probably avoid the active work area.

4. Effects on Aquatic Food Web - Only a minor, short-term impact on the food web is anticipated. This impact would extend beyond the construction period until the recolonization of buried areas had occurred.

5. Effect on Special Aquatic Sites - No special aquatic sites are to be significantly impacted.

6. Threatened and Endangered Species - The piping plover (Charadrius melodus), a Federal and State threatened species, could potentially be impacted by the proposed project. This bird nests on the beach, however, no nesting sites have been observed within the project area. Several species of threatened and endangered sea turtles may be migrating through the sand borrow area depending on the time of year. Sea turtles have been known to become entrained and subsequently destroyed by suction hopper dredges. Use of a hopper dredge during a time of high likely presence in the area could potentially entrain and destroy a sea turtle(s).

7. Other Wildlife - The proposed plan would not affect other wildlife.

8. Actions to minimize impacts - Impacts to benthic resources can be minimized at the borrow area by dredging in a manner as to avoid the creation of deep pits, using one borrow area as the primary source of initial fill, and alternating locations of periodic dredging. Impacts to Federal and State threatened piping plover can be avoided or minimized by establishing a buffer zone around a piping plover nest(s) and limiting construction outside of the nesting season. Depending on the timing of the dredging and the type of dredge to be used, potential impacts to Federal and State threatened or endangered sea turtles can be minimized by employing NMFS approved sea turtle monitors, hardened dragarm deflectors, and trawling.

F. Proposed Disposal Site Determinations

1. Mixing Zone Determination

   a. Depth of water - 0 to 20 feet mean low water
   b. Current velocity - Generally under 3 feet per second
   c. Degree of turbulence - Moderate

d. Stratification - None

e. Discharge vessel speed and direction - Not applicable

f. Rate of discharge - Typically this is estimated to be 780 cubic yards per hour

g. Dredged material characteristics - medium-fine sand

h. Number of discharge actions per unit time - Continuous over the construction period

2. Determination of compliance with applicable water quality standards - Prior to construction, a Section 401 Water Quality Certificate and consistency concurrence with the State's Coastal Zone Management Program will be obtained from the State of New Jersey.

3. Potential Effects on Human Use Characteristics -

a. Municipal and private water supply - No effect

b. Recreational and commercial fisheries - Short-term effect during construction; there would be a loss of surf clam stocks within the borrow area from dredging.

c. Water related recreation - Short-term effect during construction

d. Aesthetics - Short-term effect during construction

e. Parks, national and historic monuments, national seashores, wilderness areas, etc. - No effect

G. <u>Determination of Cumulative Effects on the Aquatic Ecosystem</u>- None anticipated.

H. <u>Determination of Secondary Effects on the Aquatic Ecosystem</u> Any secondary effects would be minor and of short duration.

III. <u>FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE</u>

A. No significant adaptation of the Section 404(b)(1) Guidelines were made relative to this evaluation.

B. The alternative measures considered for accomplishing the project objectives are detailed in Section 3 of the document of which this 404(b)(1) analysis is a part.

C. A water quality certificate will be obtained from the New Jersey Department of Environmental Protection.

D. The proposed beach nourishment will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

E. The proposed beach nourishment will comply with the

Endangered Species Act of 1973. Informal coordination procedures have been completed.

F. The proposed beach nourishment will not violate the protective measures for any Marine Sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

G. The proposed beach nourishment will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on lifestages of aquatic life and other wildlife dependent on aquatic ecosystems; aquatic ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values will not occur.

H. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include selection of borrow material that is low in silt content, has little organic material, and is uncontaminated.

I. On the basis of the guidelines, the proposed disposal site for the dredged material is specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

9.0 CLEAN AIR ACT STATEMENT OF CONFORMITY

CLEAN AIR ACT
STATEMENT OF CONFORMITY
BRIGANTINE INLET TO GREAT EGG HARBOR INLET
ABSECON ISLAND INTERIM STUDY
ATLANTIC COUNTY, NEW JERSEY

Based on the conformity analysis in the subject report I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP), the Environmental Protection Agency had no adverse comments under their Clean Air Act authority. No comments from the air quality management district were received during coordination of the draft feasibility report. The proposed project would comply with Section 176 (c)(1) of the Clean Air Act Amendments of 1990.

6 Aug 96
Date

Robert B. Keyser
Lieutenant Colonel, Corps of Engineers
District Engineer

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11.0 INDEX

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CONCLUSIONS

As a requirement in completing the feasibility study, a public notice shall be issued to inform all interested parties of the plan discussed herein. Because the design of the recommended plan is not technically complex and is essentially complete, a typical Design Memorandum would not be required before the initiation of construction. The only technical work remaining consists of additional geotechnical sampling/testing of the borrow site to finalize the site dimensions of the sand source for initial beachfill, and final environmental coordination and documentation which can be accomplished concurrent with preparation of plans and specifications for construction. In the event this study leads to Federal construction, the costs for these activities shall be reimbursed by the non-Federal sponsor as a project cost shared item.

The recommended storm damage reduction plan generally extends the entire oceanfront length of Absecon Island, and portions of Atlantic City's inlet frontage, for a total length of 44,425 feet, and consists of:

- For Atlantic City, a berm extending seaward 200 ft. from the design line at an elevation of +8.5 ft. NGVD. For Ventnor, Margate and Longport, a berm extending seaward 100 ft from the design line at an elevation of +8.5 ft. NGVD. Both berm plans have a foreshore slope of 1V:30H to mean low water (MLW). From MLW seaward the slope parallels the bottom out to the depth of closure.
- On top of the berm plans would be constructed a dune with a top width of +16 ft. NGVD and a top width of 25 ft. in Atlantic City and a dune with a top elevation of +14 ft. NGVD and a top width of 25 ft. in Ventnor, Margate and Longport. The landward and seaward slope of the dune face is 1V:5H.
- A total sand fill quantity of 6,174,000 cubic yards is needed for the initial fill placement.
- Two sections of timber bulkhead with stone revetment 1) from Oriental Avenue to Atlantic Avenue totaling 1,050 l.f. and 2) from Madison Avenue to Melrose Avenue totaling 550 l.f. Both bulkheads are designed with a top elevation of +14 ft. NGVD.
- 91 acres of planted dune grass and 63,675 l.f. of sand fence for entrapment of sand on the dune and delineating walkovers and vehicle access ramps would be required. Dune walkovers and vehicle access ramps over the dune will be maintained in their present fashion.
- Renourishment of approximately 1,666,000 cubic yards of sand fill from the offshore borrow area every 3 years for the 50 year project life.
- Beachfill for the proposed project is available from three offshore borrow areas containing approximately 20,050,000 cubic yards of suitable beachfill material. The borrow areas are located 1) approximately 1 mile offshore of Longport, 2) Absecon Inlet and 3) approximately 1 mile offshore of Atlantic City.

- To properly assess the functioning of the proposed plan, monitoring of the placed beachfill, borrow areas, shoreline, wave and littoral environment is included with the plan. Environmental monitoring is being addressed through coordination with other interested agencies, and is included in the Final Environmental Impact Statement for the project.

If this project were to go to construction, the Federal Government would contribute 65% of the first cost of the selected plan, which is currently estimated to be $52,146,000. Periodic nourishment of the selected plan would be similarly cost shared.

The plan described above is subject to modification at the discretion of the Commander, HQUSACE.

RECOMMENDATION

In making the following recommendation, I have given consideration to all significant aspects in the overall public interest, including environmental, social effects, economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests. A plan has been identified that is technically sound, economically justified, and socially and environmentally acceptable; however, the current Administration's budgetary policy precludes further Federal participation in the design and construction of hurricane and storm damage reduction projects.

The recommendations contained herein reflect the information available at the time and current Departmental policies governing formulation of individual projects. These recommendations may be modified before they are transmitted to the Congress. However, prior to transmittal to the Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Robert B. Keyser
Lieutenant Colonel, Corps of Engineers
District Engineer

SUBJECT: New Jersey Shore Protection Study; Brigantine Inlet to Great Egg Harbor Inlet-Absecon Island Interim Feasibility Study and Final Environmental Impact Statement.

Commander, North Atlantic Division, Corps of Engineers. ATTN: CENAD-ET-P, 90 Church Street, New York, New York 10007-2979 AUG 20 1996

FOR COMMANDER, HQUSACE ATTN: Policy Review Branch, Policy Review and Analysis Division, Kingman Building, Fort Belvoir, Virginia 22060-5576

I generally concur in the findings of the District Commander. The plan developed is technically sound, economically justified and environmentally acceptable; however, the current Administration's budgetary policy withholds further Corps of Engineers participation in design and construction of hurricane and storm damage reduction projects.

Milton Hunter

MILTON HUNTER
Major General, USA
Commanding

APPENDIX C

ENVIRONMENTAL INVESTIGATIONS AND COORDINATION

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PLANNING AID REPORT

BRIGANTINE INLET TO ABSECON INLET,

BRIGANTINE INLET TO GREAT EGG HARBOR INLET REACH,

NEW JERSEY SHORE PROTECTION RECONNAISSANCE STUDY

Prepared for
U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, Pennsylvania 19106-2991

Prepared by
U.S. Department of the Interior
Fish and Wildlife Service
Pleasantville, New Jersey

August, 1991

Preparers: Adrian Villaruz and Peter Benjamin
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Fish and Wildlife Enhancement
927 North Main Street (Bldg. D)
Pleasantville, New Jersey 08232
(609) 646-9310

IN REPLY REFER TO:

August 30, 1991

Lt. Colonel Kenneth H. Clow
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, Pennsylvania 19106-2991

Dear Colonel Clow:

This is the planning aid report by the Fish and Wildlife Service (Service) for Brigantine Inlet to Absecon Inlet, Brigantine Inlet to Great Egg Harbor Inlet Reach, New Jersey Shore Protection Reconnaissance Study. This report is provided in accordance with a Fiscal Year-1991 scope-of-work agreement between the Service and the Philadelphia District. The report provides technical assistance only and is not the document required of the Secretary of the Interior by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Planning aid is valid only for the described conditions and will have to be reviewed for revisions if significant environmental changes or changes in the proposed project take place prior to initiation.

The federally listed endangered peregrine falcon (Falco peregrinus) nests on structures in the Edwin B. Forsythe National Wildlife Refuge, Brigantine Division, and hunts for prey throughout much of the project area. Significant numbers of migrant peregrine falcons utilize the Brigantine Island back bay marshes. The federally endangered bald eagle (Haliaeetus leucocephalus) feeds extensively in coastal salt marshes during migrations. Eagle use of these marshes reaches a peak in winter. The federally threatened piping plover (Charadrius melodus) nests on Brigantine Island's coastal beaches. Additional federally endangered or threatened species found within the study area are under the jurisdiction of the National Marine Fisheries Service. Appendix A provides federally listed and candidate species in New Jersey. A list of State endangered species is included in Appendix B.

Additional information regarding this report can be provided by John Staples of my staff. We request that any written comments on this report be provided to us within 30 days.

Sincerely,

Clifford G. Day
Supervisor

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APPENDICES

1. INTRODUCTION

This Fish and Wildlife Service (Service) planning aid report has been prepared in conjunction with a Philadelphia District, Army Corps of Engineers (Corps) Fiscal Year-1991 scope-of-work agreement, and is submitted for the Brigantine Inlet to Great Egg Harbor Inlet Reach of the New Jersey Shore Protection Reconnaissance Study currently being conducted by the Corps (Figure 1). The report focuses on Brigantine Island from Brigantine Inlet south to Absecon Inlet, east to the Atlantic shore, and west to the mainland to include Brigantine Channel, Grassy Bay, Reed's Bay, and portions of Absecon Bay in Atlantic County, New Jersey (Figure 2). It identifies the study area's fish and wildlife resources and the potential impacts to those resources from proposed shore protection and water quality improvement activities, as well as opportunities for fish and wildlife habitat enhancement and deficiencies in the current state of knowledge concerning the study area's resources.

2. PROJECT DESCRIPTION

The Corps has initiated a reconnaissance-level study to investigate coastal processes to reduce shoreline erosion and storm damage, and to preclude further degradation of coastal water quality. The study has been divided into six reaches along the New Jersey Atlantic Coast. This portion of the study is located within the Brigantine Inlet to Great Egg Harbor Inlet reach, and will examine shore protection, flood control, and water quality problems attributed to natural and man-made conditions, and identify potential solutions along the shore and back bays of Brigantine Island and Absecon Island. Hydraulic modeling may be utilized to better understand the flow dynamics of the back bays and help identify the areas where water quality problems persist.

The study is being sponsored by the New Jersey Department of Environmental Protection. The identified problem areas and potential solutions for each will be evaluated, and the benefits and costs of one potentially feasible plan will be computed for each site. This study will result in determination of whether the planning process should proceed further into a feasibility phase. Environmental factors will be given major consideration during plan development.

3. METHODS AND PROCEDURES

The information for this planning aid report was compiled from searches of Service library and office files, personal interviews, and telephone contacts. Interviews were held with David Jenkins and Lawrence Niles, N.J. Endangered and Nongame Species Program; James Joseph, N.J. Bureau of Shellfisheries; Eugene Keller, N.J. Bureau of Coastal Engineering; and, John McClain, N.J. Bureau of Marine Fisheries. Other personnel from the N.J. Division of Fish, Game and Wildlife and the N.J. Bureau of Marine Water Classification and Analysis were contacted via telephone.

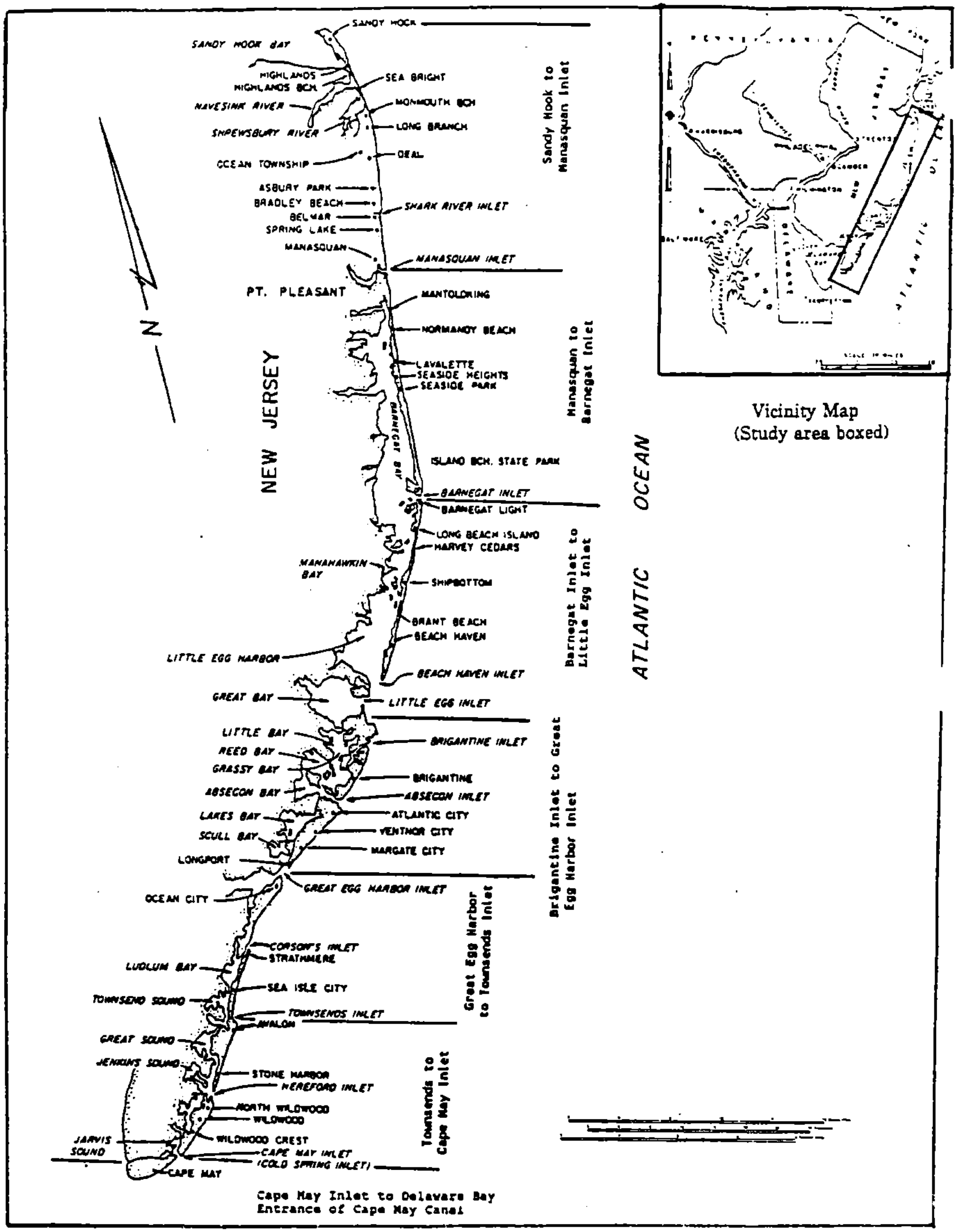


Figure 1 Map of New Jersey Coas_al Reaches.

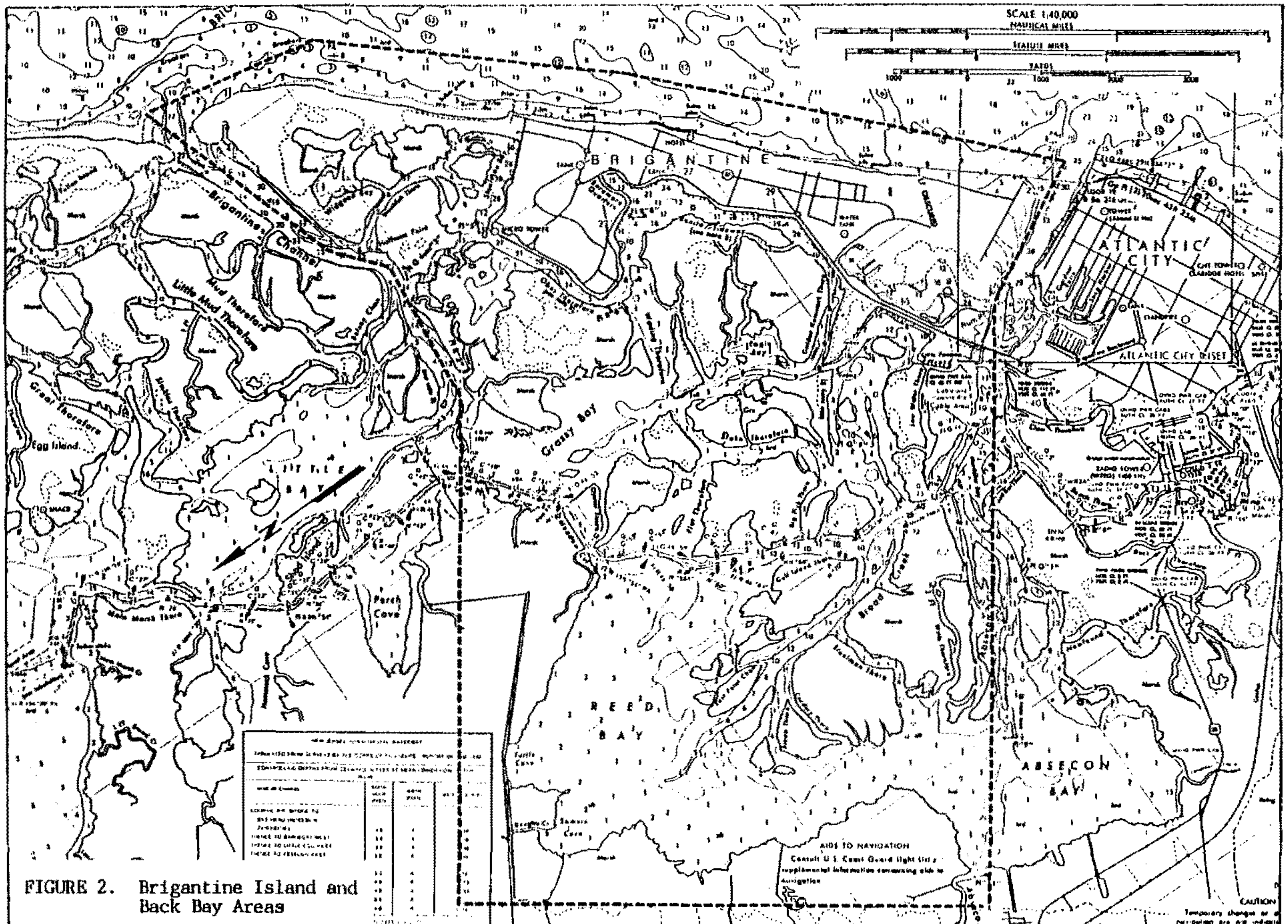


FIGURE 2. Brigantine Island and Back Bay Areas

4. FISH AND WILDLIFE RESOURCES

Finfish

Shore zones and estuaries provide migratory pathways and spawning, feeding, and nursery areas for many commercial and sport fish, as well as comprising the primary habitat for many forage fish. An intensive ecological study conducted for the proposed Atlantic Generating Station sampled fish from the waters of Little Egg Harbor, Great Bay, and the Mullica River; Absecon, Brigantine, Little Egg, and Beach Haven inlets; and the ocean from the surf in the vicinity of Little Egg Inlet to an area 6 miles from shore (Thomas et al., 1973, 1974, and 1975; Milstein and Thomas, 1976). The study involved year-round sampling to determine the temporal and spatial distribution of fish. Methods for collection ranged from 25-foot and 16-foot trawls, to seines, plankton nets, and gill nets. Over 152 species of fish were collected from samples taken in 1972 (Table 1). Sampling continued through 1975. Species composition, diversity, and abundance within the samples varied with the season, location, and the type of collection method used. These variables, as well as the results of the sampling, were analyzed and discussed in greater detail within the report for the ecological study (Thomas et al., 1973, 1974, and 1975; Milstein and Thomas, 1976).

Ocean trawl surveys using a 25-foot semiballoon trawl were conducted in the area between the Holgate Peninsula and the Brigantine Inlet, seaward to a distance of about 5.5 miles. The trawl surveys collected 69 species in 1972, and 76 species in 1973 and 1974. Bay anchovy (Anchoa mitchilli), red hake (Urophycis chuss), windowpane flounder (Scophthalmus aquosus), weakfish (Cynoscion regalis), spotted hake (Urophycis regia), and silver hake (Merluccius bilinearis) were among the most abundant fish taken for all years, with bay anchovy being the dominant fish in the surveys (Thomas et al., 1973, 1974, and 1975).

Collections made in the Atlantic Ocean off Little Egg Inlet with 500-foot gill nets in 1973, and 900-foot gill nets in 1974 and 1975, documented 33 species, 35 species, and 25 species, respectively. The most numerous species were Atlantic menhaden (Brevoortia tyrannus), smooth dogfish (Mustelus canis), spiny dogfish (Squalus acanthias), weakfish, American shad (Alosa sapidissima), striped searobin (Prionotus evolans), spot (Leiostomus xanthurus), and white perch (Morone americana) (Milstein and Thomas, 1976; Thomas et al., 1974, and 1975).

Sampling for the proposed Atlantic Generating Station utilized seines of various sizes to survey habitats such as tide pools, mud-sand shores, protected sand beaches, surf zones, and nearshore zones in Great Bay, Little Egg Harbor, and Brigantine Inlet. Forage fish such as Atlantic silverside (Menidia menidia), banded killifish (Fundulus diaphanus), tidewater silverside (Menidia peninsulae), sheepshead minnow (Cyprinodon variegatus), striped killifish (Fundulus majalis), northern pipefish (Syngnathus fuscus), and fourspine stickleback (Apeltes quadracus), dominated the surveys. Juveniles of Florida pompano (Trachinotus carolinus), bay anchovy, Atlantic menhaden, weakfish, white perch, spot, northern kingfish (Menticirrhus saxatilis), white mullet (Mugil curema), winter flounder (Pseudopleuronectes americanus), and

Table 1. Alphabetical listing by common name of all fish species collected in the vicinity of Little Egg Inlet, New Jersey from January, 1972 to January, 1973.

Alewife - Alosa pseudoharengus
American eel - Anguilla rostrata
American shad - Alsoa sapidissima
Atlantic cod - Gadus morhua
Atlantic croaker - Micropogon undulatus
Atlantic cutlassfish - Trichiurus lepturus
Atlantic herring - Clupea harengus
Atlantic mackerel - Scomber scombrus
Atlantic menhaden - Brevoortia tyrannus
Atlantic moonfish - Vomer setapinnis
Atlantic needlefish - Strongylura marina
Atlantic silverside - Menidia menidia
Atlantic spadefish - Chaetodipterus faber
Atlantic sturgeon - Acipenser oxyrhynchus
Atlantic thread herring - Opisthonema oglinum
Banded drum - Larimus fasciatus
Banded killifish - Fundulus diaphanus
Banded rudderfish - Seriola zonata
Bay anchovy - Anchoa mitchilli
Bigeye scad - Selar crumenophthalmus
Blackbanded sunfish - Enneacanthus chaetodon
Black drum - Pogonias cromis
Black sea bass - Centropristis striata
Blueback herring - Alosa aestivalis
Bluefish - Pomatomus saltatrix
Bluegill - Lepomis macrochirus
Bluerunner - Caranx crysos
Bluespotted cornetfish - Fistularia tabacaria
Bluespotted sunfish - Enneacanthus gloriosus
Bluntnose stingray - Dasyatis sayi
Brown bullhead - Ictalurus nebulosus
Bullnose ray - Myliobatis freminvillei
Butterfish - Peprilus triacanthus
Chain pickerel - Esox niger
Chub mackerel - Scomber japonicus
Clearnose skate - Raja eglanteria
Cobia - Rachycentron canadum
Conger eel - Conger oceanicus
Creek chubsucker - Erimyzon oblongus
Crevalle jack - Caranx hippos
Cunner - Tautogolabrus adspersus
Darter goby - Gobionellus boleosoma
Dusky shark - Carcharhinus obscurus
Fat sleeper - Dormitator maculatus
Feather blenny - Hypsoblennius hentzi
Florida pompano - Trachinotus carolinus
Flounder - Bothus robinsi (MS name)
Fourbeard rockling - Enchelyopus cimbrius
Foureye butterflyfish - Chaetodon capistratus
Fourspine stickleback - Apeltes quadracus
Fourspot flounder - Paralichthys oblongus
Frigate mackerel - Auxis thazard
Glasseye snapper - Priacanthus cruentatus
Golden shiner - Notemigonus crysoleucas
Goosefish - Lophius americanus
Gray snapper - Lutjanus griseus
Gray triggerfish - Balistes capriscus
Grubby - Myoxocephalus aenaeus
Haddock - Melanogrammus aeglefinus
Halfbeak - Hyporhamphus unifasciatus
Hickory shad - Alosa mediocris
Hogchoker - Trinectes maculatus
Inquiline seasnail - Liparis inquilinus
Inshore lizardfish - Synodus foetens
King mackerel - Scomberomorus cavalla
Ladyfish - Elops saurus
Largemouth bass - Micropterus salmoides
Lined seahorse - Hippocampus erectus
Little skate - Raja erinacea
Little tunny - Euthynnus alletteratus
Longhorn sculpin - Myoxocephalus octodecemspinosus
Lookdown - Selene vomer
Mummichog - Fundulus heteroclitus
Naked goby - Gobiosoma bosci
Northern kingfish - Menticirrhus saxatilis
Northern pipefish - Syngnathus fuscus
Northern puffer - Spheroides maculatus
Northern searobin - Prionotus carolinus
Northern sennet - Sphyraena borealis
Northern stargazer - Astroscopus guttatus
Ocean pout - Macrozoarces americanus
Ocean sunfish - Mola sp.
Orange filefish - Aluterus schoepfi
Oyster toadfish - Opsanus tau
Palometa - Trachinotus goodei
Permit - Trachinotus falcatus
Pinfish - Lagodon rhomboides
Planehead filefish - Monacanthus hispidus
Pollock - Pollachius virens
Pumpkinseed - Lepomis gibbosus
Rainwater killifish - Lucania parva
Red drum - Sciaenops ocellata
Redfin pickerel - Esox americanus
Red hake - Urophycis chuss
Rock gunnel - Pholis gunnellus
Rough scad - Trachurus lathami

Source: Thomas et al., 1973

Table 1. (cont.)

Rough silverside - Membras martinica	White sucker - Catostomus commersoni
Roughtail stingray - Dasyatis centroura	Whitefin sharksucker - Echeneis neucratoides
Round herring - Etrumeus teres	Windowpane - Scophthalmus aquosus
Round scad - Decapterus punctatus	Winter flounder - Pseudopleuronectes americanus
Sand lance - Ammodytes sp.	Witch flounder - Glyptocephalus cynoglossus
Sandbar shark - Carcharhinus milberti	Yellow perch - Perca flavescens
Scup - Stenotomus chrysops	Yellowtail flounder - Limanda ferruginea
Seaboard goby - Gobiosoma ginsburgi	
Sea lamprey - Petromyzon marinus	
Sea raven - Hemitripterus americanus	
Sergeant major - Abudefduf saxatilis	
Sheepshead minnow - Cyprinodon variegatus	
Short bigeye - Pristigenys alta	
Silver anchovy - Engraulis eurystole	
Silver hake - Merluccius bilinearis	
Silver perch - Bairdiella chrysura	
Smallmouth flounder - Etropus microstomus	
Smooth dogfish - Mustelus canis	
Smooth hammerhead - Sphyrna zygaena	
Snakeblenny - Lumpenus lumpretaeformis	
Snapper - Lutjanus sp.	
Snowy grouper - Epinephelus niveatus	
Spiny butterfly ray - Gymnura altavela	
Spiny dogfish - Squalus acanthias	
Spot - Leiostomus xanthurus	
Spotfin butterflyfish - Chaetodon ocellatus	
Spotfin fillifish - Fundulus luciae	
Spotfin mojarra - Eucinostomus argenteus ?	
Spotted goatfish - Pseudupeneus maculatus	
Spotted hake - Urophycis regius	
Spotted scorpionfish - Scorpaena plumieri	
Striped anchovy - Anchoa hepsetus	
Striped bass - Morone saxatilis	
Striped burrfish - Chilomycterus schoepfi	
Striped cusk-eel - Rissola marginata	
Striped killifish - Fundulus majalis	
Striped mullet - Mugil cephalus	
Striped searobin - Prionotus evolans	
Summer flounder - Paralichthys dentatus	
Tautog - Tautoga onitis	
Tessellated darter - Etheostoma olmstedi	
Threespine stickleback - Gasterosteus aculeatus	
Tidewater silverside - Menidia beryllina	
Tiger shark - Galeocerdo cuvieri	
Weakfish - Cynoscion regalis	
White catfish - Ictalurus catus	
White hake - Urophycis tenuis	
White mullet - Mugil curema	
White perch - Morone americana	

windowpane flounder were also collected in the seines (Milstein and Thomas, 1976; Thomas et al., 1973, 1974, and 1975).

Additional sampling in the back bay areas behind Brigantine Island were conducted by the N.J. Bureau of Fisheries (1979). Of the 59 species of fish taken in these surveys (Table 2), the Atlantic silverside was the most abundant. Bay anchovy, spot, mummichog (Fundulus heteroclitus), striped killifish, bluefish (Pomatomus saltatrix), white mullet, weakfish, winter flounder, smooth dogfish, windowpane flounder, and Atlantic menhaden were also collected, and are listed here in descending order of relative abundance as documented from the sampling. Ichthyoplanktonic sampling by the N.J. Bureau of Fisheries (1979) detected 23 species of fish in the egg, larval, and juvenile stages of growth within the back bay systems of Atlantic County (Table 3).

The coastal waters around Brigantine Island support significant commercial and recreational fisheries (N.J. Bureau of Fisheries, 1979). Commercially important species include Atlantic menhaden, silver hake, red hake, summer flounder, yellowtail flounder (Limanda ferruginea), scup (Stenotomus chrysops), weakfish, butterfish (Peprilus triacanthus), bluefin tuna (Thunnus thynnus), Atlantic mackerel (Scomber scombrus), and American shad. Important recreational fisheries located in the inshore waters off of Brigantine Island include striped bass (Morone saxatilis), black sea bass (Centropristis striata), weakfish, bluefish, tautog (Tautoga onitis), and summer flounder (Paralichthys dentatus). The N.J. Bureau of Marine Fisheries (McClain, 1982, 1983, and 1984) has additional data on the relative abundance of selected sport fish in Great Bay obtained from surveys conducted in July through October of 1982, 1983, and 1984.

Benthic Organisms

Benthic macroinvertebrates are important food organisms in the estuarine environment and, along with primary producers, perform a crucial role in supporting extensive food webs encompassing other forms of fish and wildlife. The diversity and composition of benthic communities is often a reliable indicator of the overall quality of any particular habitat for supporting life (N.J. Bureau of Fisheries, 1979).

Sampling associated with the proposed Atlantic Generating Station utilized trawls, clam dredges, and ponar grabs to determine the species composition, abundance, weight, and spatial and temporal distribution of benthic macroinvertebrates in the vicinity of the Mullica River estuary, Great Bay, Little Egg Inlet, and the ocean from Brigantine Island to Long Beach Island and 5 miles seaward (Milstein and Thomas, 1976). Appendix C contains a list of over 250 macroinvertebrate species collected in the surveys.

A benthic study conducted by the N.J. Bureau of Fisheries (1979) in the bays and inlets from Great Bay to Great Egg Harbor Inlet inventoried the macroscopic epifauna and infauna and examined the composition of the sediments in which they lived. The study report discussed the relationship of the organisms to sediment composition as well as the condition of benthic

Table 2. List of Common and Scientific Names of Fishes Taken in the Study Area.

Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
American sandlance	*Ammodytes americanus*
American shad	*Alosa sapidissima*
Atlantic croaker	*Micropogon undulatus*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic silverside	*Menidia menidia*
Bay anchovy	*Anchoa mitchilli*
Black sea bass	*Centropristis striata*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Bluntnose stingray	*Dasyatis sayi*
Butterfish	*Peprilus triacanthus*
Crevalle jack	*Caranx hippos*
Cunner	*Tautogolabrus adspersus*
Fourspine stickleback	*Apeltes quadracus*
Grubby	*Myoxocephalus aenaeus*
Halfbeak	*Hyporhamphus unifasciatus*
Hardtail jack	*Caranx crysos*
Hogchoker	*Trinectes maculatus*
Lined seahorse	*Hippocampus erectus*
Lookdown	*Selene vomer*
Mummichog	*Fundulus heteroclitus*
Naked goby	*Gobiosoma bosci*
Northern kingfish	*Menticirrhus saxatilis*
Northern pipefish	*Syngnathus fuscus*
Northern puffer	*Sphoeroides maculatus*
Northern searobin	*Prionotus carolinus*
Orange filefish	*Aluterus schoepfi*
Oyster toadfish	*Opsanus tau*
Permit	*Trachinotus falcatus*
Pollock	*Pollachius viren*
Pumpkinseed	*Lepomis gibbosus*
Red hake	*Urophycis chuss*
Rough silverside	*Membras martinica*
Sandbar shark	*Carcharhinus milberti*
Scup	*Stenotomus chrysops*
Sheepshead minnow	*Cyprinodon variegatus*
Silver hake	*Merluccius bilinearis*
Smallmouth flounder	*Etropus microstomus*
Smooth dogfish	*Mustelus canis*
Spot	*Leiostomus xanthurus*
Spotted hake	*Urophycis regius*
Striped anchovy	*Anchoa hepsetus*
Striped burrfish	*Chilomycterus schoepfi*
Striped cusk-eel	*Rissola marginata*
Striped killifish	*Fundulus majalis*
Striped mullet	*Mugil cephalus*
Striped searobin	*Prionotus evolans*
Summer flounder	*Paralichthys dentatus*

Source: N.J. Bureau of Fisheries, 1979

Table 2. continued

Tautog	*Tautoga onitis*
Threespine stickleback	*Gasterosteus aculeatus*
Weakfish	*Cynoscion regalis*
White hake	*Urophycis tenuis*
White mullet	*Mugil curema*
White perch	*Morone americana*
Windowpane	*Scophthalmus aquosus*
Winter flounder	*Pseudopleuronectes americanus*
Yellow perch	*Perca flavescens*

Table 3. A List of Common and Scientific Names of Fishes Taken During the Ichthyoplankton Survey in the Back Bay Systems in Atlantic County from March 1977 to November 1977.

Scientific Name	Common Name
Ammodytes sp.	Sand lance
Anchoa mitchilli	Bay anchovy
Anguilla rostrata	American eel
Cynoscion regalis	Weakfish
Family Engraulidae	Anchovies
Fundulus heteroclitus	Mummichog
Family Gobiidae	Gobies
Gobiosoma bosci	Naked goby
Hippocampus sp.	Seahorse
Lophius americanus	Goosefish
Menidia beryllina	Tidewater silverside
Menidia menidia	Atlantic silverside
Micropogon undulatus	Atlantic croaker
Family Monacanthidae	Filefish
Myoxycephalus aenaeus	Grubby
Opsanus tau	Oyster toadfish
Paralichthys dentatus	Summer flounder
Prionotus sp.	Searobin
Pseudopleuronectes americanus	Winter flounder
Scophthalmus aquosus	Windowpane
Syngnathus fuscus	Northern pipefish
Family Synodontidae	Lizardfishes
Synodus foetens	Inshore lizardfish

Source: N.J. Bureau of Fisheries, 1979

communities in specific substrates. Although some species were associated with certain sediment types, no strong correlations between species diversity and density, and sediment composition were found.

Benthic organisms of interest in the study area include surf clam (Spisula solidissima), hard clam (Mercenaria mercenaria), soft clam (Mya arenaria), American oyster (Crassostrea virginica), blue mussel (Mytilus edulis), blue crab (Callinectes sapidus), and horseshoe crab (Limulus polyphemus). The surf clam supports the largest molluscan fishery in New Jersey, accounting for 58% (by weight) of the State's total commercial landing in 1988 (Ward, 1990). This catch represented over 82% of the total Mid-Atlantic area catch for 1988, with a commercial value of over 17.0 million dollars.

A study conducted from July, 1989, to June, 1990, surveyed New Jersey's standing stock of surf clams (Ward, 1990). The study examined abundance, size composition, and recruitment within the surf clam population. The harvest zones between Barnegat Inlet and Absecon Inlet were estimated in 1989 to contain 3,319,000 bushels of surf clams, or 40 percent of the State's standing stock. Surveys by Milstein and Thomas (1976) found surf clams in all types of substrate, although the highest densities were recorded in very fine sand bottom.

The area between Little Beach and Absecon Inlet (which includes Brigantine Island) from the surf to one nautical mile off-shore has been designated a conservation zone by the Surf Clam Advisory Committee (SCAC) (Figure 3). The SCAC is a joint committee formed by the N.J. Bureau of Shellfisheries and representatives of the commercial surf clam industry to determine harvesting regulations. No surf clam harvesting is allowed within a conservation zone in order to promote recruitment and growth of current stock.

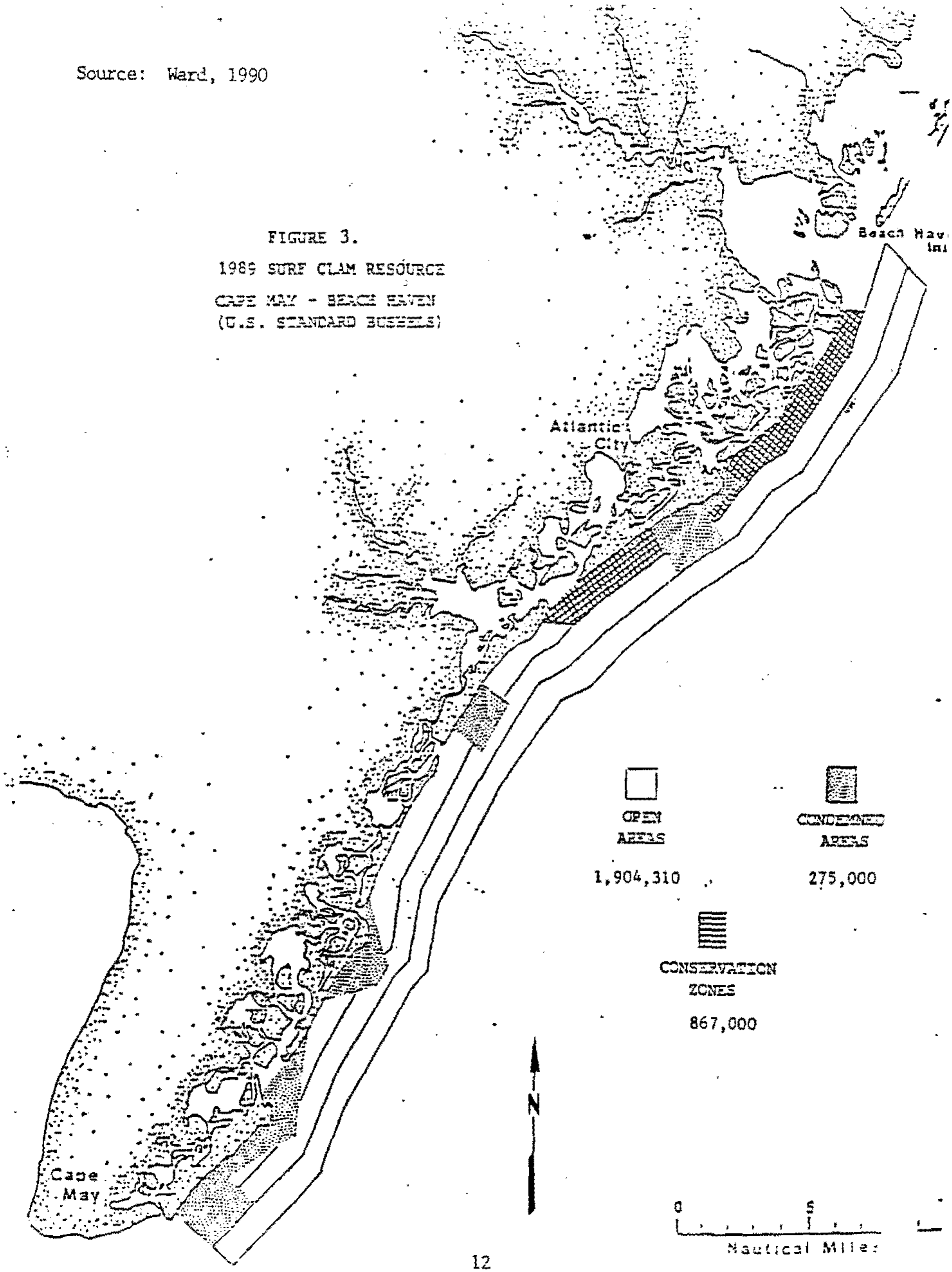
The hard clam is the most economically important shellfish of the back bays, supporting both recreational and commercial fisheries (N.J. Bureau of Fisheries, 1979). Adult hard clams are found in the intertidal and subtidal zones of bays and lower estuaries. Data on the location and densities of hard clam beds within the back bay areas of Brigantine Island are limited. A 1990 hard clam survey found areas with moderate (0.20-0.49 clams/sq. ft.) to high densities ($\geq$ 0.50 clams/sq. ft.) of hard clam in the waterway immediately behind Brigantine Island (Joseph, 1990).

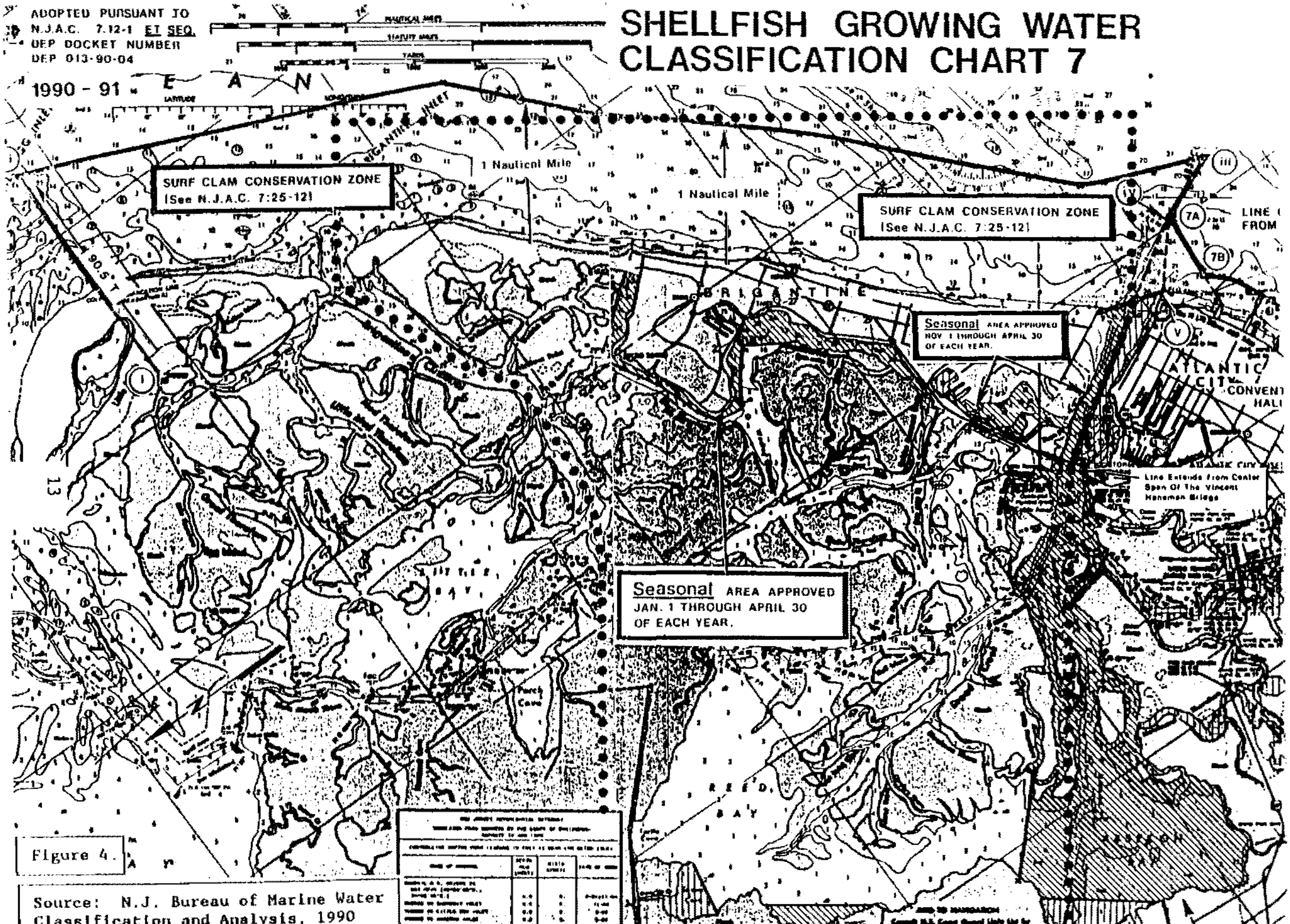
Besides supporting some of the best hard clam resources in the State, the bays of Atlantic County also support other species of shellfish (N.J. Bureau of Fisheries, 1979). American oysters can be found throughout the numerous creeks and bays of the study area, but are not usually present in commercially harvestable densities. Soft clams and blue mussels are harvested for recreation; occasionally, areas are located with sufficient densities to allow a commercial harvest.

Based on water quality testing, the New Jersey Division of Water Resources has mapped areas open and closed to shellfishing within New Jersey (Figure 4) (N.J. Bureau of Marine Water Qualification and Analysis, 1990). Due to degraded water quality, harvesting shellfish within the back bay waterways directly adjacent to Brigantine Island is seasonally restricted. The Absecon

Source: Ward, 1990

FIGURE 3.
1989 SURF CLAM RESOURCE
CAPE MAY - BEACH HAVEN
(U.S. STANDARD BUSHELS)





13

Figure 4.

Source: N.J. Bureau of Marine Water Classification and Analysis, 1990

Inlet, Absecon Channel, and Absecon Bay areas are also seasonally restricted for shellfish harvest. However, most of Little Bay, Grassy Bay, and Reed Bay, except for isolated areas, are approved for shellfish harvest.

The blue crab is distributed throughout the back bays, estuaries, and inshore zones of the study area, and represents a valuable commercial and recreational fishery. In 1975, over 96,000 pounds of blue crabs were commercially harvested in Atlantic County (Milstein and Thomas, 1976). Blue crabs seasonally concentrate in the deeper channels and inlets where they burrow into the mud to overwinter.

No commercial fishery for horseshoe crabs exists in the study area (Scarlett, pers. com.). Horseshoe crabs lay their eggs in the intertidal zones of beaches and marshes. These eggs are an important food resource for migrating shorebirds during the spring migration.

Waterfowl

The coastal marshes of the Brigantine Island study area provide important winter habitat for migratory waterfowl. Midwinter waterfowl surveys (MWS) have been conducted along the coast of New Jersey for over 40 years (New Jersey Division of Fish, Game and Wildlife, 1990a). Between 1985 and 1990, 14 species of waterfowl were recorded in the Reeds Bay/Absecon Bay area during the MWS (Table 4). The mean number of Atlantic brant (Branta bernicla) recorded annually in the Reeds Bay/Absecon Bay area during the 1985-1990 MWS was 18,650 (SE = 5,379; range 2,400 - 34,000). This represents 22% of the total Atlantic brant New Jersey winter population. Similarly, 30% of the northern shoveler (Anas clypeata) recorded in New Jersey during this time period were seen in the Reeds Bay/Absecon Bay area (mean = 167/year; SE = 80.3; range 0 - 400).

Over the last decade the coastal marshes of New Jersey have supported over 35 percent of the Atlantic Flyway American black duck (A. rubripes) wintering population (N.J. Division of Fish, Game and Wildlife, 1990a). The mean number of black ducks recorded per year in the Reeds Bay/Absecon Bay area during the 1985-1990 MWS was 3,567 (SE = 967.1; range 2,000 - 8200). This represents 4.3% of the total New Jersey winter population of black ducks.

Several species of waterfowl also breed within the study area. A 1989 survey (N.J. Division of Fish, Game and Wildlife, 1990b) estimated 197 black duck, and 13 mallard (A. platyrhynchos) breeding pairs in the area. In 1990, the survey estimated 92 black duck, and 13 gadwall (A. strepera) breeding pairs.

The North American Waterfowl Management Plan of 1986 (NAWMP) was established to reverse the decline of wetlands and waterfowl by establishing goals for conserving wetland habitats and restoring waterfowl populations. The loss and degradation of waterfowl habitat has been identified by the NAWMP as the major waterfowl management problem in North America. Under the Atlantic Coast Joint Venture of the NAWMP, a cooperative agreement between the United States and Canada, areas containing valuable waterfowl habitat are designated as "focus areas" to be protected. The study area is included within the

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Table 4. Number of individuals of 14 waterfowl species seen during midwinter waterfowl surveys in the Reeds Bay/Absecon Bay area, New Jersey, 1985 - 1990 (N.J. Division of Fish, Game and Wildlife, 1990a).

	Year						
Species	1985	1986	1987	1988	1989	1990	Total
Mallard	700	700	200	500	400	200	2700
Black Duck	3300	2300	8200	3600	2000	2000	21400
Widgeon	300	0	100	300	0	0	700
Green-winged Teal	200	0	400	500	0	0	1100
Shoveler	400	0	200	400	0	0	1000
Pintail	100	0	200	300	0	0	600
Scaup	300	200	200	1900	0	0	2600
Goldeneye	0	0	0	0	0	100	100
Bufflehead	900	400	800	700	500	400	3700
Oldsquaw	0	100	100	0	0	0	200
Merganser	200	100	400	200	200	200	1300
Brant	11000	2400	8500	24000	32000	34000	111900
Snow Goose	8000	0	0	4000	0	0	12000
Canada Goose	100	0	300	0	100	0	500

Brigantine/Barnegat Wetlands Focus area, and encompasses approximately 23,400 acres of back bay wetlands.

The Emergency Wetlands Resources Act of 1986 (PL 99-645) directs the Department of the Interior to identify specific wetland sites that should receive priority attention for acquisition by federal and State agencies using Land and Water Conservation Fund monies. The purpose of the EWRA is to promote wetlands conservation through cooperative efforts with private interests and local, State, and federal governments for the management and protection of wetlands. The entire back bay region behind Brigantine Island, which includes the study area, has been designated by the Service as a Priority Wetlands Site.

Colonial Nesting Waterbirds

Colonial nesting waterbirds nest on the islands and marshes of the Brigantine Island study area. Coastal marshes provide feeding habitat, while islands in the back bay areas provide nesting habitat that is protected from mammalian predators. Herons, egrets, and ibis nest on shrubby or forested marsh islands, many of which are the result of dredge spoil operations. A 1989 survey (Jenkins et al., 1989) of the Atlantic coast of New Jersey found 14 species of colonial waterbirds nesting in 39 separate colonies in the Reeds Bay/Absecon Bay area (Appendix D). Species recorded include: little blue heron (_Egretta caerulea_), tri-colored heron (_E. tricolor_), black-crowned night heron (Nycticorax nycticorax), yellow-crowned night heron (N. violaceus), great egret (Casmerodius albus), snowy egret (E. thula), cattle egret (Bubulcus ibis), glossy ibis (Plegadis falcinellus), herring gull (Larus argentatus), great black-backed gull (L. marinus), laughing gull (L. atricilla), common tern (Sterna hirundo), least tern (S. antillarum), and Forster's tern (S. forsteri). The survey noted that black-crowned and yellow-crowned night heron populations have declined in the last decade, while egret, ibis, and gull populations have remained stable or increased.

The ocean-front beach area of southern Brigantine island supports one of the largest least tern breeding colonies in the State. A 1990 ground survey reported 200 pairs of nesting least terns on Brigantine Island between Absecon Inlet and 40th street (Jenkins, pers. com.).

Shorebirds

The Brigantine Island study area's coastal marshes provide important resting and feeding areas for migrating shorebirds. In 1990, the Brigantine Division of the Edwin B. Forsythe National Wildlife Refuge recorded 40,000 shorebirds in May during the peak of the spring migration, and 20,000 shorebirds in October during the peak of the fall migration (U.S. Fish and Wildlife Service, 1990). Common species occurring in the coastal marshes of New Jersey include ruddy turnstone (Arenaria interpres), willet (Catoptrophorus semipalmatus), red knot (Calidris canutus), dunlin (C. alpina), semipalmated sandpiper (C. pusilla), short-billed dowitcher (Limnodromus griseus), and black-bellied plover (Pluvialis squatarola).

Raptors

The coastal marshes of the Brigantine Island study area support several resident species of raptors. Peregrine falcons (Falco peregrinus) hacked from the Edwin B. Forsythe National Wildlife Refuge continue to breed in the hacking towers (Taylor, pers. com.). These individuals remain in the study area for most of the year. The osprey (Pandion haliaetus), a State threatened species, is a breeding season resident that utilizes tall structures near open water for nesting. Occasionally, barn owls (Tyto alba) will nest in the Refuge's peregrine falcon hacking tower, and in other structures near open marsh habitat. The red-tailed hawk (Buteo jamaicensis) is a year-round resident frequently seen soaring over marshes. The northern harrier (Circus cyaneus) is a State resident breeder in coastal marshes; however, there are currently no known harrier nesting sites within the study area (Niles, pers. com.). The breeding population of the northern harrier is listed by the State as endangered.

Although many species of raptors migrate through the study area during fall migration, several species remain throughout the winter. Both the bald eagle (Haliaeetus leucocephalus) and golden eagle (Aquila chrysaetos) frequent coastal marshes where wintering waterfowl provide an abundance of prey. The northern harrier, rough-legged hawk (Buteo lagopus), and short-eared owl are common winter residents that utilize the coastal marshes for hunting small mammals.

Other Wildlife

Several species of marine mammals inhabit the offshore and back bay waters of the study area (Schoelkopf, pers. com.). Seals such as the harbor seal (Phoca vitulina), grey seal (Halichoerus grypus), ringed seal (P. hispida), harp seal (P. groenlandica), and hooded seal (Cystophora cristata) are occasionally seen in the back bay areas between December and June. Bottle-nosed dolphin (Tursiops truncatus) are commonly seen in Absecon Inlet in the summer, while striped dolphin (Stenella coeruleoalba) and harbor porpoise (Phocoena phocoena) are occasionally observed in the spring. Annually since 1984, one or more right whales (Balaena glacialis) have been seen in Absecon Inlet during the summer. Other marine mammals that occur in the area include pilot whale (Globicephela macrorhynchus), pygmy sperm whale (Kogia breviceps), Atlantic white-sided dolphin (Lagenorhynchus acutus) and Risso's dolphin (Grampus griseus).

Several mammalian species inhabit the marsh fringe and uplands of Brigantine Island. These include: river otter (Lutra canadensis), whitetail deer (Odocoileus virginianus), eastern cottontail (Sylvilagus floridanus), muskrat (Ondatra zibethicus), red fox (Vulpes vulpes), raccoon (Procyon lotor), opossum (Didelphis virginiana), meadow vole (Microtus pennsylvanicus), white-footed mouse (Peromyscus leucopus), and striped skunk (Mephitis mephitis). No data are available regarding the distribution and abundance of these species within the study area.

Federal and State Listed Endangered and Threatened Species

Federally designated endangered and threatened species found within the study area include the bald eagle (endangered), peregrine falcon (endangered), piping plover (threatened), Kemp's Ridley Turtle (Lepidochelys kempii) (endangered), green turtle (Chelonia midas) (threatened), hawksbill turtle (Eretmochelys imbricata) (endangered), leatherback turtle (Dermochelys coriacea) (endangered), and loggerhead turtle (Caretta caretta) (threatened).

Migratory raptor surveys conducted during fall migration by the Cape May Observatory at Cape May Point have shown a dramatic increase in observations of bald eagles and peregrine falcons since 1976. Over the past 10 years, peregrine sightings have undergone a five-fold increase while bald eagle sightings have doubled (U.S. Fish and Wildlife Service, 1988).

Peregrines utilize coastal beaches and salt marshes within the study area extensively during migration, and to a lesser extent in summer and winter. Resident peregrine falcons, most likely hacked from the Edwin B. Forsythe National Wildlife Refuge, remain within the study area for most of the year. One pair nests annually in a hacking tower on the Refuge's Brigantine Division (Taylor, pers. com.). The nesting success of this pair is significantly greater than that of peregrines nesting on the Refuge's Barnegat Division. Another pair has been recorded nesting on a casino building in Atlantic City, which is just south of the study area (Jenkins, pers. com.). Peregrine activity has also been observed on the Brigantine Boulevard Bridge to Brigantine Island.

Migrating and overwintering bald eagles utilize the study area's coastal marshes where they feed on waterfowl. However, no eagles are known to nest in the area (Niles, pers. com.).

The piping plover nests on sparsely vegetated, sandy beaches in New Jersey. The entire eastern shore of Brigantine Island could potentially support piping plover nests. However, annual surveys conducted by the New Jersey Division of Fish, Game and Wildlife reveal that highest plover use occurs on the southern tip of Brigantine Island along Absecon Inlet and the adjacent, ocean-front beaches (Jenkins, pers. com.). These areas regularly support about 15 pairs of plovers. Occasionally, plovers will nest along public beaches to the north. The natural area on the northern tip of Brigantine Island generally does not support more than one or two pairs of plovers despite its undeveloped state. High recreational vehicle use in this area may be a contributing factor to the lack of nesting plovers. Two areas to the north of the study area, Little Beach Island and Holgate Peninsula, are utilized regularly by plovers for breeding (Taylor, pers. com.).

Other federally endangered and threatened species that frequent the Brigantine Island study area include several aquatic species, although none of them are known to breed there. The National Marine Fisheries Service has jurisdiction over federally listed sea turtles such as the Atlantic (Kemp's) Ridley, hawksbill, leatherback, loggerhead, and green turtles, and the endangered marine mammals such as the blue whale (Balaenoptera musculus), finback whale (B. physalus), sei whale (B. borealis), humpback whale (Megaptera novaeangliae), sperm whale (Physeter catodon), and right whale. Generally, only the humpback and right whale are found inshore (Coogan, pers. com.). For further information regarding federally listed seaturtles and marine mammals, coordination with the National Marine Fisheries Service is recommended.

The northern diamondback terrapin (Malaclemys terrapin terrapin) is a federal candidate species found in the bays, marshes, and tidal flats of the study area. The terrapin breeds in vegetated dunes above the high tide line. A list of federally designated and candidate species found in New Jersey are provided in Appendix A.

Various State listed threatened and endangered species inhabit or frequent Brigantine Island, adjacent back bays, and estuarine marsh habitats. Appendix B contains a list of the N.J. State endangered species and the status of the State's native, nongame species. Appendix D provides locations of colonial nesting water birds, many of which are listed by the State as endangered or threatened. Appendices E and F contain lists of State listed species that have been recorded within the area depicted by the Oceanville, N.J. Quadrangle, U.S. Geological Survey (USGS) topographic map, and State listed species that occur in Atlantic County, respectively (N.J. Division of Parks and Forestry, 1989). Maps prepared by the N.J. Division of Fish, Game, and Wildlife (Clark, 1988) depicting the locations of shorebird, colonial water bird, and endangered species habitat on USGS quad maps are available from the N.J. Division of Coastal Resources.

The osprey (Pandion haliaetus) is a State listed species that nests on towers and channel markers adjacent to open water. The study area supports several breeding pairs (N.J. Division of Fish, Game and Wildlife, 1990c).

The New Jersey Natural Heritage Program maintains records of the known locations and sightings of State and federally listed species, and candidate species within New Jersey. The Program should be contacted at the following address for site-specific information concerning endangered and threatened species:

Mr. Thomas Breden
Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625
(609/984-0097)

The N.J. Division of Fish, Game and Wildlife, Endangered and Nongame Species Program, should also be contacted for information regarding specific nesting sites for State endangered or threatened species, or colonial waterbird rookeries.

5. POTENTIAL IMPACTS OF SHORELINE PROTECTION

Shoreline protection efforts that include extraction of material from offshore borrow areas, related beach nourishment operations, and installation of bulkheads, groins, and similar structures may result in a variety of impacts to fish, shellfish, and wildlife. Successful implementation of such measures may slow or prevent erosion of shorelines and thereby alter conversion of beaches, dunes, estuarine wetlands, and other habitats to shallow and deep water habitats. Additional impacts of such efforts are described below.

Extraction from Borrow Areas

Similar to other dredging, extraction of material from borrow areas has been documented as causing environmental impacts that may adversely affect fish and wildlife populations and the food chains on which they depend. Kantor (1984) provides a review of dredging impacts specific to New Jersey. These impacts can generally be subdivided into those affecting the water column and those affecting the bottom substrate. Adverse water quality impacts from material extraction include increased turbidity, changes in temperature and oxygen demand, and release or resuspension of toxins and bacteria. These factors may cause direct mortality to fish and shellfish, disrupt fish migrations, hamper fish and shellfish spawning, make shellfish unsuitable for human consumption, and reduce primary productivity. Settling of suspended sediment may result in smothering of shellfish and other benthic organisms downcurrent from the project site.

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Bottom impacts include removal of existing benthic communities, change in circulation patterns, and modification of patterns of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing. These depressions can accumulate fine-grained sediments and organic material, including contaminants. Reduced flushing, combined with decomposition of organic materials, can lead to low oxygen conditions in such depressions. Originally occurring or different benthic forms may eventually recolonize the area of extraction depending on the water quality and substrate present.

The type of equipment used and the time of year extraction occurs may greatly influence the nature and extent of potential adverse impacts in the water column. For example, the use of hydraulic dredging reduces Service concerns regarding short-term adverse impacts on water quality at and near the site of dredging, but hydraulic dredging may impact eggs and young fish or other slow-moving organisms unable to avoid entrainment. The entrainment of sea turtles has also been documented as an adverse impact of hydraulic dredging (Coogan, pers. com.). The National Marine Fisheries Service has jurisdiction over endangered sea turtles and should be contacted if hydraulic dredging is proposed. Conversely, mechanical dredging has greater impacts on turbidity and dissolved oxygen at the dredge site, but, if conducted during periods of low seasonal biological productivity, adverse impacts to organisms can be minimized.

Beach Nourishment

Beach nourishment will cause a range of water quality impacts similar to extraction of material. Increased turbidity, changes in temperature and oxygen demand, and release or resuspension of toxins and bacteria may take place in waters adjacent to nourishment sites.

Additionally, habitats present on beach nourishment sites may be lost or altered, with displacement or burying of existing organisms. Macrofauna of nourished beaches may recover slowly. Other impacts may include changes in beach profile and water circulation both on nourished beaches and adjacent unnourished beaches. Small nourishment projects and projects where beachfill is consistent with preexisting beach material should recover more rapidly (Reilly and Bellis, 1983). Reducing project size may not only increase the recruitment rate for organisms at the nourished beach, but may reduce the potential for increased human/nesting bird conflicts. Nourished beaches increase the amount of open, sandy habitat that favor beach nesting birds such as black skimmers, least terns, and piping plovers. Unfortunately, high levels of human activity on nourished beaches often eliminates nesting success (U.S. Fish and Wildlife Service, 1988).

Bulkheads and Groins

Mulvihill et al. (1980) discuss environmental impacts of bulkheads, groins, and related structures (seawalls, revetments, rip-rap, and jetties). Placement of such structures can cause temporary increase in turbidity with associated impacts mentioned above. In addition, bulkheading and associated backfilling may eliminate shallow water, intertidal habitat, vegetated wetlands, and transition zones from beach or wetland to upland. Groin placement may result in lost benthic habitat in the area covered, but may provide new types of habitat in its place. Bulkheads and other structures may reflect wave energy, destabilizing adjacent bottom areas and destroying existing vegetation. Once in place, bulkheads and groins may alter patterns of nearshore water circulation, causing increased accretion and erosion along adjacent unstabilized shorelines. This may cause impacts to shallow water, submerged aquatic beds, tidal flats, vegetated wetlands and other habitats.

A potentially positive impact of these structures is their potential to provide substrate for the attachment of sessile marine organisms, which in turn may support fish and other marine life. This could be a beneficial effect in areas of low biological activity.

6. OPPORTUNITIES FOR HABITAT ENHANCEMENT AND WATER QUALITY IMPROVEMENT

Opportunities exist for habitat enhancement within the study area. However, the Brigantine Island back bays support an extensive system of marshes and shallow water habitats; alteration of these highly productive, natural systems should be avoided (Castelli, pers. com.). Subsequently, habitat enhancement efforts should be limited to managing dredged material disposal sites and beach nourishment sites to benefit wildlife, and to improving water quality through control of non-point source pollution.

Habitat Enhancement

Numerous dredge material disposal sites are located within the study area (Keller, pers. com.). Due to abandonment or inactivity, many of these sites have revegetated. Upland islands that have succeeded into a scrub-shrub dominated community provide nesting habitat for many colonial nesting waterbirds (Appendix D), as well as critical resting and feeding areas for migrating passerines. Disturbance of these woody-shrub dominated sites should be avoided.

Many previously disturbed, upland sites have become dominated by common reed (Phragmites communis). Dense, monotypic stands of Phragmites offer little food value to a majority of native wildlife species. Habitat enhancement efforts should be directed at controlling Phragmites while promoting the growth of native woody shrubs. Reutilization of Phragmites-dominated dredge disposal sites followed by active management involving intensive Phragmites control could potentially improve the habitat quality of these sites for wildlife.

Dikes that surround dredged material disposal sites often impound water and create wetlands. Some disposal sites enclose sufficient drainage area to support permanent freshwater wetlands. Where possible, these wetland areas should be maintained. Where site disturbance is unavoidable, efforts should be made to reestablish wetlands through the judicial application of appropriate dredged material. Wetlands creation and maintenance can also be applied to existing upland disposal sites. Active management involving Phragmites control, replanting with wildlife vegetation that provides food and cover for wildlife, and monitoring should reinforce all such attempts.

The N.J. Bureau of Coastal Engineering sponsored a study (Frederic R. Harris, Inc., 1989) to inventory potential dredged material disposal sites along the intercoastal waterways from the Manasquan River to Cape May Harbor, New Jersey. Numerous sites were evaluated to determine their suitability for dredged material disposal. Two sites within the Brigantine Island study area were subsequently identified. Both sites are dominated by Phragmites and may be suitable for disposal-related enhancement.

Aerial photography should be used to identify potential sites for wildlife habitat enhancement. The N.J. Division of Coastal Resources is currently identifying and mapping all wetlands within the State using 1:20,000 color infrared aerial photographs taken in March, 1991. These and other aerial photographs should be used to identify Phragmites-dominated, upland areas within the Brigantine Island study area.

A high demand for recreational beaches has reduced the amount of relatively undisturbed, sparsely vegetated beaches that beach nesting birds such as the black skimmer, least tern, and piping plover require for breeding. Beach nourishment can create suitable habitat for beach nesting birds; however, high levels of human activity in these areas can limit nesting success. In large beach nourishment projects, human intrusion should be restricted from portions of freshly nourished beaches to permit birds to nest successfully.

Water Quality Improvement

The N.J. Division of Water Resources, Bureau of Marine Water Classification and Analysis, conducts regular water quality surveys throughout the State's coastal waters to determine areas that are safe for shellfish harvesting. Areas that suffer degraded water quality due to high fecal coliform counts are subject to seasonal restrictions or special restrictions, or are condemned for shellfishing. This information is depicted on the State Of New Jersey, Shellfish Growing Water Classification Charts published by the Bureau of Marine Water Classification and Analysis (1990). The charts for 1990 to 1991, indicate that harvesting shellfish in the back bay waterways directly behind Brigantine Island is seasonally restricted (Figure 4). Surface water runoff from Brigantine Island is believed to be the contributing factor for water quality degradation in this waterway (Connell, pers. com.). Other waters within the study area that experience high fecal coliform levels include Absecon Inlet, Absecon Channel, Absecon Bay, Somers Cove, and the cove due east of the Seaview Golf Resort. Fertilizer, pesticide, and herbicide runoff from additional golf courses proposed for the adjacent areas could have adverse impacts on the study area's water quality, and could result in State condemnation of shellfish growing waters.

The Atlantic Ocean at Brigantine Island is believed to have excellent water quality (Suoninen, pers. com.). This part of the ocean receives no point

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source discharges and little direct urban runoff from Brigantine Island. Additional water quality sampling associated with the State's Coastal Monitoring Program was conducted quarterly from July 1989, to March 1991. Samples were taken from Little Egg Inlet (excluding Great Bay) to Absecon Inlet (Connell, pers. com.). Levels of ammonium nitrate and nitrite, total nitrogen, dissolved oxygen, salinity, suspended solids, and organo-phosphates, as well as temperature and Secchi disk depths, were recorded. However, funding was withdrawn before the study could be completed and conclusions drawn.

Opportunities for water quality improvement should focus on reducing pollutant levels by elimination or reduction at the source. Efforts to reduce pollution by altering natural flow dynamics may create unforeseen adverse impacts on fish and wildlife resources and should be avoided. Reducing pollutant input is recommended as the most effective method for improving water quality; specific recommendations will depend on studies to identify sources.

7. DATA GAPS AND RECOMMENDATIONS FOR FUTURE STUDIES

Predicting the long-term impacts of shore protection measures requires a thorough understanding of the physical environment and the biological communities being affected. Hydraulic modeling should be conducted to predict and avoid potential impacts of bulkheads, groins, or other structural methods on vegetated wetlands, submerged aquatic beds, or tidal flats. The effects of beach nourishment on benthic communities are not well understood. Preconstruction baseline studies should assess all relevant aspects of the environment at potential borrow areas and nourishment sites. Long-term monitoring and comparisons with control sites should be integrated into study design. The Service's Fish and Wildlife Coordination Act Report for the Corp's Atlantic Coast of New Jersey - Sea Bright to Ocean Township Beach Erosion Control Study (U.S. Fish and Wildlife Service, 1988) discusses informational needs to predict beach nourishment impacts and provides some guidelines in designing impact assessment studies, such as sampling of finfish and benthic fauna, use of control areas, schedules for sampling, and follow-up monitoring.

Additional data on water quality conditions throughout the study area are needed. Future studies, especially in the back bay areas, should identify any point and non-point sources and types of pollutants and suggest methods to reduce the levels of these pollutants. Hydraulic modeling to understand existing flow dynamics may help to identify means to reduce pollutant levels. Coastal water quality testing, consistent with the State's former Coastal Monitoring Program, should be continued to determine if water quality problems exist along the Atlantic coastal area.

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APPENDIX A

Federally Listed Endangered and Threatened Species and Candidate Species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED SPECIES** is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED SPECIES** is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

FISHES

Sturgeon, shortnose*	*Acipenser brevirostrum*	E

REPTILES

Turtle, Atl. Ridley*	*Lepidochelys kempii*	E
Turtle, green*	*Chelonia mydas*	T
Turtle, hawksbill*	*Eretmochelys imbricata*	E
Turtle, leatherback*	*Dermochelys coriacea*	E
Turtle, loggerhead*	*Caretta caretta*	T

BIRDS

Eagle, bald	*Haliaeetus leucocephalus*	E
Falcon, Am. peregrine	*Falco peregrinus anatum*	E
Falcon, Arctic peregrine	*Falco peregrinus tundrius*	T
Plover, piping	*Charadrius melodus*	T
Tern, roseate	*Sterna dougallii dougallii*	E

MAMMALS

Whale, blue*	*Balaenoptera musculus*	E
Whale, finback*	*Balaenoptera physalus*	E
Whale, humpback*	*Megaptera novaeangliae*	E
Whale, right*	*Balaena glacialis*	E
Whale, sei*	*Balaenoptera borealis*	E
Whale, sperm*	*Physeter catodon*	E

INVERTEBRATES

Dwarf wedge mussel	*Alasmodonta heterodon*	E+
Beetle, northeastern beach tiger	*Cicindela dorsalis dorsalis*	T+
Butterfly, Mitchell satyr	*Neonympha m. mitchellii*	E+

PLANTS

Pogonia, small whorled	*Isotria medeoloides*	E
Swamp pink	*Helonias bullata*	T
Orchid, eastern prairie fringed	*Platanthera leucophaea*	T+
Knieskern's beaked rush	*Rhynchospora knieskernii*	T

STATUS:

E: endangered species
T: threatened species
+: presumed extirpated

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

Note: for a complete listing of Endangered and Threatened Wildlife and Plants refer to 50 CFR 17.11 and 17.12, January 1, 1989)

CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES are species that appear to warrant consideration for addition to the List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

VERTEBRATES

Turtle, bog	Clemmys muhlenbergi	2
Terrapin, northern diamondback	Malaclemys terrapin terrapin	2
Snake, northern pine	Pituophis melanoleucas melanoleucas	2
Shrike, migrant loggerhead	Lanius ludovicianus migrans	2
Bat, eastern small-footed	Myotis subulatus leibii	2
Rabbit, New England cottontail	Sylvilagus transitionalis	2
Shrew, long-tailed	Sorex dispar	2
Shrew, Tuckahoe masked	Sorex cinereus nigriculus	2
Woodrat, eastern	Neotoma floridana magister	2

INVERTEBRATES

Beetle, cobblestone tiger	Cicindela marginipennis	2
Butterfly, regal fritillary	Speyeria idalia	2
Butterfly, tawny crescent	Phyciodes batesi	2
Dragonfly, banded bog skimmer	Williamsonia lintneri	2
Moth, Albarufan dagger	Acronicta albarufa	2
Moth, Bucholz' dart	Agrotis bucholzi	2
Moth, Daecke's pyralid	Crambus daeckeellus	2*
Moth, Hebard's noctuid	Erythroecia hebardi	2
Moth, Lemmer's noctuid	Lithophane lemmeri	2
Moth, precious underwing	Catocala pretiosa	2

PLANTS

Blazingstar	Liatris borealis	2
Bog asphodel	Narthecium americanum	1
Boneset, Pine Barrens	Eupatorium resinosum	2
Bulrush, Long's	Scirpus longii	2
Butternut	Juglans cinerea	2
Chaffseed	Schwalbea americana	PE
Foxglove, false	Agalinis auriculata	2
Joint-vetch, sensitive	Aeschynomene virginica	PT
Lobelia, Boykin's	Lobelia boykinii	2

Meadowbeauty, awned	Rhexia aristosa	2
Micranthemum, Nuttall's	Micranthemum micranthemoides	1*
Morning-glory, Pickering's	Stylisma pickeringii var. pickeringii	2
Panic grass, Hirst's	Panicum hirstii	2
Pigweed, sea-beach	Amaranthus pumilus	2
Pondweed	Potamogeton confervoides	2
Rush, New Jersey	Juncus caesariensis	2
Sedge, variable	Carex polymorpha	2
Spring beauty	Claytonia sp.	2
Spurge, Darlington's	Euphorbia purpurea	2
Tick-trefoil, ground-spreading	Desmodium humifusum	2
Verbena	Verbena riparia	2?

STATUS:

1: Taxa for which the Service currently has substantial information to support the appropriateness of proposing to list the species as threatened or endangered. Development and publication of proposed rules on these species is anticipated.

2: Taxa for which information now in possession of the Service indicates that proposing to list the species as threatened or endangered is possibly appropriate, but for which conclusive data are not available to support proposed rules at this time.

PE: Proposed Endangered species

PT: Proposed Threatened species

* indicates those species for which there have been no authenticated records in New Jersey since 1963; some of these are possibly extinct, but further research is needed to determine their status with any confidence.

? indicates those species for which occurrence in New Jersey is questionable.

Note: for complete listings of taxa under review, refer to Federal Register Vol. 54, No. 4, January 6, 1989 (Animal) and Vol. 55., No. 35, February 21, 1990 (Plants).

APPENDIX B
Endangered Species List and Status List of
Nongame Wildlife Species of New Jersey

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF FISH, GAME AND WILDLIFE

Jim Florio
Governor

Scott Weiner
Commissioner

Robert McDowell
Director

Robert A. Itchmoney
Assistant Director

Jo Ann Frier-Murza, *Chief*
Endangered and Nongame Species Program

Endangered Species List and Status List of Nongame Wildlife Species of New Jersey

Last Revision

June 3, 1991

7:25-4.1 Definitions

(a) The following words and terms, when used in this subchapter, shall have the following meanings unless the context clearly indicates otherwise.

"Nongame Species" means any wildlife for which a legal hunting or trapping season has not been established in New Jersey or which has not been classified as an endangered species by statute or regulation of this State.

"Exotic mammal, bird, reptile or amphibian", means any nongame species or mammal, bird, reptile or amphibian not indigenous to New Jersey.

"Person" shall be defined to include but not limited to corporations, companies, associations, societies including non-profit organizations, firms, partnerships, joint stock companies, individuals and governmental entities.

"Department" means state's Department of Environmental Protection.

"Division" means the Division of Fish, Game and Wildlife or its successor within the Department of Environmental Protection.

"Director" means the Director of the Division of Fish, Game and Wildlife or its successor within the Department of Environmental Protection.

"Endangered" (E) means a species whose prospects for survial within the State are in immediate danger due to one or many factors: A loss of or change in habitat, over exploitation, predation, competition, disease. An endangered species requires immediate assistance or extinction will probably follow. See N.J.A.C. 7:25-4.12(b) for listing.

"Threatened" (T) means a species that may become endangered if conditions surrounding it begin to or continue to deteriorate.

"Peripheral" (P) means a species whose occurence in New Jersey is at the extreme edge of its present natural range.

"Undetermined" (U) means a species about which there is not enough information available to determine the status.

"Declining" (D) means a species which has exhibited a continued decline in population numbers over the years.

"Extirpated (Ex) means a species that formerly occurred in New Jersey, but is not known to exist within the State.

"Introduced" (I) means a species not native to New Jersey, that could not have established itself here without the assistance of man.

"Special case" means a species not known to nest regularly in New Jersey (marine reptiles) but that does occur off our shores, some occurring with regularity close to our shore or in our bays (marine reptiles and mammals).

"Stable" (S) means a species whose population is not undergoing any long term increase: decrease within its natural cycle.

"Increasing" (INC) means a species whose population has exhibited a significant increase beyond the normal range of its cycle, over a long term period.

7:25-4.13 List of endangered species.

Bog Turtle, Clemmys muhlenbergi
Atlantic Hawksbill, Eretmochelys imbricata
Atlantic Loggerhead, Caretta caretta
Atlantic Ridley, Lepidochelys kempi
Atlantic Leatherback, Dermochelys coriacea
Corn Snake, Elaphe g. guttata
Timber Rattlesnake, Crotalus h. horridus
Tremblay's Salamander, Ambystoma tremblayi
Blue-spotted Salamander, Ambystoma .aterale
Eastern Tiger Salamander, Ambystoma t. tigrinum
Pine Barrens Treefrog, Hyla andersonii
Southern Gray Treefrog, Hyla chrysoscelis
Eastern Woodrat, Neotoma floridana
Bobcat, Felis rufus
Sperm Whale, Physeter macrocephalus
Fin Whale, Balaenoptera physalus
Sei Whale, Balaenoptera borealis
Blue Whale, Balaenoptera musculus
Humpback Whale, Megaptera novaeangliae
Black Right Whale, Balaena glacialis
Pied-billed Grebe, Podilymbus podiceps (Breeding population)
Bald Eagle, Haliaeetus leucocephalus
Northern Harrier, Circus cyaneus (Breeding population)
Cooper's Hawk, Accipiter Cooperii
Red-shouldered Hawk, Buteo lineatus (Breeding population)
Peregrine Falcon, Falco peregrinus
Piping Plover, Charadrius melodus
Upland Sandpiper, Bartramia longicauda
Roseate Tern, Sterna dougallii
Least Tern, Sterna antillarum
Black Skimmer, Rynchops niger
Short-eared Owl, Asio flammeus (Breeding population)
Sedge Wren, Cistothorus platensis
Loggerhead Shrike, Lanius ludovicianus
Vesper Sparrow, Pooecetes gramineus
Henslow's Sparrow, Ammodramus henslowii
Mitchell's Satyr, Neonympha m. mitchellii
Northeastern Beach Tiger Beetle, Cicindela d. dorsalis
American Burying Beetle, Nicrophorus americanus
Dwarf Wedge Mussel, Alasmidonta heteredon

7:25-4.17 Defining status of indigenous wildlife species of New Jersey

The following table defines the status of indigenous nongame wildlife species of New Jersey:

Common Snapping Turtle	Chelydra s. serpentina	S
Common Musk Turtle	Kinosternon odoratum	S
Eastern Mud Turtle	Kinosternon s. subrubrum	U
Spotted Turtle	Clemmys guttata	U
Wood Turtle	Clemmys insculpta	T
Eastern Box Turtle	Terrapene c. carolina	S

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Map Turtle	Graptemys geographica	U
Red-bellied Turtle	Pseudemys rubriventris	U
Red-eared Turtle	Chrysemys scripta elegans	I
Eastern Painted Turtle	Chrysemys p. picta	S
Midland Painted Turtle	Chrysemys picta marginata	U
Atlantic Green Turtle	Chelonia mydas	T
Eastern Spiny Softshell	Trionyx spiniferus	I
Northern Fence Lizard	Sceloporus undulatus hyacinthinus	S
Five-lined Skink	Eumeces fasciatus	U
Ground Skink	Scincella lateralis	U
Northern Water Snake	Nerodia s. sipedon	S
Queen Snake	Regina septemvittata	U
Northern Brown Snake	Storeria d. dekayi	S
Northern Red-bellied Snake	Storeria o. occipitomaculata	S
Eastern Garter Snake	Thamnophis s. sirtalis	S
Eastern Ribbon Snake	Thamnophis s. sauritus	S
Eastern Smooth Earth Snake	Virginia v. valeriae	U
Eastern Hognose Snake	Heterodon platyrhinos	D
Northern Ringneck Snake	Diadophis punctatus edwardsi	S
Southern Ringneck Snake	Diadophis p. punctatus	S
Eastern Worm Snake	Carphophis a. amoenus	U
Northern Black Racer	Coluber c. constrictor	U
Rough Green Snake	Opheodrys aestivus	S
Eastern Smooth Green Snake	Opheodrys v. vernalis	U
Black Rat Snake	Elaphe o. obsoleta	U
Northern Pine Snake	Pituophis m. melanoleucus	T
Eastern King Snake	Lampropeltis g. getulus	U
Eastern Milk Snake	Lampropeltis t. triangulum	S
Northern Scarlet Snake	Cemophora coccinea copei	U
Northern Copperhead	Agkistrodon contortrix mokasen	U
Marbled Salamander	Ambystoma opacum	D
Jefferson Salamander	Ambystoma jeffersonianum	D
Silvery Salamander	Ambystoma platineum	D
Spotted Salamander	Ambystima maculatum	D
Red-spotted Newt	Notophthalmus v. viridescens	S
Northern Dusky Salamander	Desmognathus f. fuscus	S
Mountain Dusky Salamander	Desmognathus ochrophaeus	U
Red-backed Salamander	Plethodon c. cinereus	S
Slimy Salamander	Plethodon g. glutinosum	S
Four-toed Salamander	Hemidactylium scutatum	D
Northern Spring Salamander	Gyrinophilus p. porphyriticus	D
Northern Red Salamander	Pseudotriton r. ruber	D
Eastern Mud Salamander	Pseudotriton m. montanus	T
Northern Two-lined Salamander	Eurycea b. bislineata	S
Long-tailed Salamander	Eurycea l. longicauda	T
Eastern Spadefoot Toad	Scaphiopus h. holbrookii	D
American Toad	Bufo americanus	S
Fowler's Toad	Bufo woodhouseii fowleri	S
Northern Cricket Frog	Acris c. crepitans	U
Northern Spring Peeper	Hyla c. crucifer	S
Barking Treefrog	Hyla gratiosa	U
Northern Gray Treefrog	Hyla versicolor	S
New Jersey Chorus Frog	Pseudacris triseriata kalmi	S
Upland Chorus Frog	Pseudacris triseriata feriarum	U
Bullfrog	Rana catesbeiana	S

Carpenter Frog	Rana virgatipes	U
Green Frog	Rana clamitans melanota	S
Wood Frog	Rana sylvatica	S
Southern Leopard Frog	Rana spenocephala	S
Pickerel Frog	Rana palustris	S
Masked Shrew	Sorex cinereus	S
Tuckahoe Masked Shrew	Sorex cinereus nigriculus	U
Water Shrew	Sorex palustris	U
Smokey Shrew	Sorex fumeus	U
Long-tailed Shrew	Sorex dispar	U
Short-tailed Shrew	Blarina brevicauda	S
Least Shrew	Crytotis parva	U
Hairy-tailed Mole	Parascalops breweri	U
Eastern Mole	Scalopus aquaticus	S
Star-nosed Mole	Condylura cristata	U
Little Brown Bat	Myotis lucifugus	S
Keen Myotis	Myotis keenii	U
Small-footed Myotis	Myotis subulatus	U
Silver-haired Bat	Lasionycteris noctivagans	U
Eastern Pipistrel	Pipistrellus subflavus	U
Big Brown Bat	Eptesicus fuscus	S
Red Bat	Lasiurus borealis	S
Northern yellow bat	Lasiurus intermedius	P
Hoary Bat	Lasiurus cinereus	U
New England Cottontail	Sylvilagus transitionalis	U
Snowshoe Hare	Lepus americanus	EX
European Hare	Lepus capensis	I
Black-tailed Jackrabbit	Lepus californicus	I
Eastern Chipmunk	Tamias striatus	S
Red Squirrel	Tamiasciurus hudsonicus	S
Southern Flying Squirrel	Glaucomys volans	U
Northern Flying Squirrel	Glaucomys sabrinus	U
Marsh Rice Rat	Oryzomys palustris	S
White-footed Mouse	Peromyscus leucopus	S
Red-backed Mouse	Clethrionomys gapperi	S
Meadow Vole	Microtis pennsylvanicus	S
Pine Vole	Pitymys pinetorum	S
Southern Bog Lemming	Synaptomys cooperi	U
Black Rat	Rattus rattus	I
Brown Rat	Rattus norvegicus	I
House mouse	Mus musculus	I
Woodland Jumping Mouse	Napaeozapus insignis	U
Meadow Jumping Mouse	Zapus hudsonius	U
Porcupine	Erethizon dorsatum	INC
Gray Wolf	Canis lupus	EX
Marten	Martes americana	EX
Fisher	Martes pennanti	EX
Mountain Lion	Felis concolor	EX
Harbor Seal	Phoca vitulina	S
Harp Seal	Pagophilus groenlandica	P
Gray Seal	Halichoerus grypus	P
Hooded Seal	Cystophora cristata	P
Elk	Cervus elaphus	EX
Goose-beaked Whale	Ziphius cavirostris	U
Dense Beaked Whale	Mesoplodon densirostris	U

Gervais Beaked Whale	Mesoplodon europaeus	U
True's Beaked Whale	Mesoplodon mirus	U
Pygmy Sperm Whale	Kogia breviceps	U
Dwarf Sperm Whale	Kogia simus	U
Beluga Whale	Delphinapterus leucas	P
Bridled Spotted Dolphin	Stenella frontalis	U
Spotted Dolphin	Stenella plagiodon	U
Striped Dolphin	Stenella coeruleoalba	U
Saddle-backed Dolphin	Delphinus delphis	U
Bottle-nosed Dolphin	Tursiops truncatus	S
Atlantic Killer Whale	Orcinus orca	U
Risso's Dolphin	Grampus griseus	U
Long-finned Pilot Whale	Globicephala melaena	U
Short-finned Pilot Whale	Globicephala macrothyncus	U
Harbor Porpoise	Phocoena phocoena	U
Minke Whale	Balaenoptera acutorostrata	U

BIRDS		BREEDING STATUS	NON-BREEDING STATUS
Red-throated Loon	Gavia stellata		S
Common Loon	Gavia immer		S
Pied-billed Grebe	Podilymbus podiceps	E	S
Horned Grebe	Podiceps auritus		S
Red-necked Grebe	Podiceps grisegena		D
Cory's Shearwater	Calonectris diomedea		S
Greater Shearwater	Puffinus gravis		INC
Sooty Shearwater	Puffinus griseus		S
Wilson's Storm-petrel	Oceanites oceanicus		S
Leach's Storm-petrel	Oceanodroma leucorhoa		S
Northern Gannet	Sula bassanus		S
Brown Pelican	Pelecanus occidentalis		INC
Great Cormorant	Phalacrocorax carbo		S
Double-crested Cormorant	Phalacrocorax auritus		INC
American Bittern	Botaurus lentiginosos	T	S
Least Bittern	Ixobrychus exilis	D	S
Great Blue Heron	Ardea herodias	T	S
Great Egret	Casmerodius albus	S	S
Snowy Egret	Egretta thula	S	S
Little Blue Heron	Egretta caerulea	T	S
Tricolored Heron	Egretta tricolor	INC	S
Cattle Egret	Bubulcus ibis	INC	INC
Green-backed Heron	Butorides striatus	S	S
Black-crowned Night Heron	Nycticorax nycticorax	D	S
Yellow-crowned Night Heron	Nyctanassa violaceus	T	T
Glossy Ibis	Plegadis falcinellus	D	S
Fulvous Whistling Duck	Dendrocygna bicolor		P
Tundra Swan	Cygnus columbianus		INC
Mute Swan	Cygnus olor	I	
Eurasian Wigeon	Anas penelope		S
King Eider	Somateria spectabilis		S
Harlequin Duck	Histrionicus histrionicus		S
Black Vulture	Coragyps atratus	INC	S
Turkey Vulture	Cathartes aura	S	S
Osprey	Pandion haliaetus	T	T
American Swallowtail Kite	Elanoides forficodus		INC

Mississippi Kite	Ictinia mississippiensis		INC
Northern Harrier	Circus cyaneus	E	U
Sharp-shinned Hawk	Accipiter striatus	U	U
Northern Goshawk	Accipiter gentilis	T	T
Red-shouldered Hawk	Buteo lineatus	E	T
Broad-winged hawk	Buteo platypterus	S	S
Red-tailed Hawk	Buteo jamaicensis	INC	INC
Rough-legged Hawk	Buteo lagopus		S
Golden Eagle	Aquila chrysaetos		S
American Kestrel	Falco sparverius	INC	S
Merlin	Falco columbarius		S
Yellow Rail	Coturnicops noveboracensis		U
Black Rail	Laterallus jamaicensis	T	T
King Rail	Rallus elegans	U	U
Black-bellied Plover	Pluvialis squatarola		S
Lesser Golden Plover	Pluvialis dominica		S
Wilson's Plover	Charadrius wilsonia		EX
Semipalmated Plover	Charadrius semipalmatus		S
Killdeer	Charadrius vociferus	S	S
American Oystercatcher	Haematopus palliatus	INC	S
Black-necked Stilt	Himantopus mexicanus		INC
American Avocet	Recurvirostra americana		INC
Greater Yellowlegs	Tringa melanoleuca		S
Lesser Yellowlegs	Tringa flavipes		S
Solitary Sandpiper	Tringa solitaria		S
Willet	Catoptrophorus semipalmatus	INC	S
Spotted Sandpiper	Actitis macularia	S	S
Eskimo Curlew	Numenius borealis		EX
Whimbrel	Numenius phaeopus		S
Hudsonian Godwit	Limosa haemastica		D
Marbled Godwit	Limosa fedoa		D
Ruddy Turnstone	Arenaria interpres		S
Red Knot	Calidris canutus		D
Sanderling	Calidris alba		D
Semipalmated Sandpiper	Calidris pusillus		S
Western Sandpiper	Calidris mauri		S
Least Sandpiper	Calidris minutilla		S
White-rumped Sandpiper	Calidris fuscicollis		S
Baird's Sandpiper	Calidris bairdii		D
Pectoral Sandpiper	Calidris melanotos		S
Purple Sandpiper	Calidris maritima		INC
Dunlin	Calidris alpina		INC
Curlew Sandpiper	Calidris ferruginea		S
Stilt Sandpiper	Calidris himantopus		INC
Buff-breasted Sandpiper	Tryngites subruficollis		S
Ruff	Philomachus pugnax		INC
Short-billed Dowitcher	Limnodromus griseus		S
Long-billed Dowitcher	Limnodromus scolopaceus		S
Wilson's Phalarope	Phalaropus tricolor		INC
Red-necked Phalarope	Phalaropus lobatus		S
Red Phalarope	Phalaropus fulicarias		S
Pomarine Jaeger	Stercorarius pomarinus		S
Parasitic Jaeger	Stercorarius parasiticus		S
Long-tailed Jaeger	Stercorarius longicaudus		S
Laughing Gull	Larus atricilla	S	S

Little Gull	Larus minutus		S
Common Black-headed Gull	Larus ridibundus		S
Bonaparte's Gull	Larus philadelphia		S
Ring-billed Gull	Larus delawarensis		INC
Herring Gull	Larus argentatus	S	S
Iceland Gull	Larus glaucoides		S
Lesser Black-backed Gull	Larus fuscus		INC
Glaucous Gull	Larus hyperboreus		S
Great Black-backed Gull	Larus marinus	INC	S
Black-legged Kittiwake	Rissa tridactyla		S
Gull-billed Tern	Sterna nilotica		S
Caspian Tern	Sterna caspia		S
Royal Tern	Sterna maximus		S
Common Tern	Sterna hirundo	D	S
Forster's Tern	Sterna forsteri	INC	S
Black Tern	Childonias niger		S
Dovekie	Alle alle		D
Thick-billed Murre	Uria iomvia		D
Razorbill	Alca torda		D
Rock Dove	Columba livia	I	
Mourning Dove	Zenaida macroura	INC	S
Black-billed Cuckoo	Coccyzus erythropthalmus	S	S
Yellow-billed Cuckoo	Coccyzus americanus	S	S
Common Barn Owl	Tyto alba	S	S
Eastern Screech Owl	Otus asio	S	S
Great Horned Owl	Bubo virginianus	INC	S
Snowy Owl	Nyctea scandiaca		S
Barred Owl	Strix varia	T	T
Long-eared Owl	Asio otus	T	T
Short-eared Owl	Asio flammeus	E	U
Northern Saw-whet Owl	Aegolius acadicus	S	S
Common Nighthawk	Chordeiles minor	S	S
Chuck-will's-widow	Caprimulgus carolinensis	INC	S
Whipporwill	Caprimulgus vociferus	D	S
Chimney Swift	Chaetura pelagica	S	S
Ruby-throated Hummingbird	Archilochus colubris	D	S
Belted Kingfisher	Ceryle alcyon	S	S
Red-headed Woodpecker	Melanerpes erythrocephalus	T	T
Red-bellied Woodpecker	Melanerpes carolinus	INC	S
Yellow-bellied Sapsucker	Sphyrapicus varius		S
Downy Woodpecker	Picoides pubescens	S	S
Hairy Woodpecker	Picoides villosus	S	S
Northern Common Flicker	Colaptes auratus	S	S
Pileated Woodpecker	Dryocopus pileatus	S	S
Olive-sided Flycatcher	Contopus borealis		S
Eastern Wood Pewee	Contopus virens	S	S
Yellow-bellied Flycatcher	Empidonax flaviventris		S
Acadian Flycatcher	Empidonax virescens	INC	S
Alder Flycatcher	Empidonax alnorum	S	S
Willow Flycatcher	Empidonax traillii	INC	S
Least Flycatcher	Empidonax minimus	S	S
Eastern Phoebe	Sayornis phoebe	S	S
Great Crested Flycatcher	Myiarchus crinitus	S	S
Western Kingbird	Tyrannus verticalis		S
Eastern Kingbird	Tyrannus Tyrannus	D	D

Horned Lark	Eremophila alpestris	D	S
Purple martin	Progne subis	D	S
Tree Swallow	Tachycineta bicolor	S	S
Northern Rough-winged Swallow	Stelgidopteryx serripennis	S	S
Bank Swallow	Riparia riparia	S	S
Cliff Swallow	Hirundo pyrrhonota	T	S
Barn Swallow	Hirundo rustica	S	S
Blue Jay	Cyanocitta cristata	INC	S
Fish Crow	Corvus ossifragus	INC	S
Common Raven	Corvus corax		EX
Black-capped Chickadee	Paurs atricapillus	INC	S
Carolina Chickadee	Parus carolinensis	S	S
Boreal Chickadee	Parus hudsonicus		S
Tufted Titmouse	Parus bicolor	INC	S
Red-breasted Nuthatch	Sitta canadensis	S	S
White-breasted Nuthatch	Sitta carolinensis	S	S
Brown Creeper	Certhia americana	S	S
Carolina Wren	Thryothorus ludovicianus	S	S
House Wren	Troglogytes aedon	S	S
Winter Wren	Troglodytes troglodytes		S
Marsh Wren	Cistothorus palustris	D	S
Golden-crowned Kinglet	Regulus satrapa	S	S
Ruby-crowned Kinglet	Regulus calendula		S
Blue-gray Gnatcatcher	Polioptila caerulea	INC	S
Eastern Bluebird	Sialia sialis	S	S
Veery	Catharus fuscescens	S	S
Gray-cheeked Thrush	Catharus minimus		S
Swainson's Thrush	Catharus ustulatus		S
Hermit Thrush	Catharus guttatus	S	S
Wood Thrush	Hylocichla mustelina	S	S
American Robin	Turdus migratorius	S	S
Catbird	Dumetella carolinensis	S	S
Northern Mockingbird	Mimus polyglottos	INC	S
Brown Thrasher	Toxostoma rufum	D	S
Water Pipit	Anthus spinoletta		S
Cedar Waxwing	Bombycilla cedrorum	S	S
Northern Shrike	Lanius exubitor		S
European Starling	Sturnus vulgaris	I	
White-eyed Vireo	Vireo griseus	D	S
Solitary Vireo	Vireo solitarius	S	S
Yellow-throated Vireo	Vireo flavifrons	S	S
Warbling Vireo	Vireo gilvus	S	S
Philadelphia Vireo	Vireo philadelphicus		S
Red-eyed Vireo	Vireo olivaceus	INC	INC
Blue-winged Warbler	Vermivora pinus	INC	S
Golden-winged Warbler	Vermivora chrysoptera	D	S
Tennesee Warbler	Vermivora peregrina		S
Orange-crowned Warbler	Vermivora celata		S
Nashville Warbler	Vermivora reficapilla	S	S
Northern Parula	Parula americana	P	S
Yellow Warbler	Dendroica petechia	S	S
Chestnut-sided Warbler	Dendroica pensylvanica	S	S
Magnolia Warbler	Dendroica magnolia	S	S
Cape May Warbler	Dendroica tigrina		S
Black-throated Blue Warbler	Dendroica caerulescens	S	S

Yellow-rumped Warbler	Dendroica coronata		S
Black-throated Green Warbler	Dendroica virens	S	S
Blackburnian Warbler	Dendroica fusca	S	S
Yellow-throated Warbler	Dendroica dominica	S	S
Pine Warbler	Dendroica pinus	S	S
Prairie Warbler	Dendroica discolor	S	S
Palm Warbler	Dendroica palmarum		S
Bay-breasted Warbler	Dendroica castanea		S
Blackpoll Warbler	Dendroica striata		S
Cerulean Warbler	Dendroica cerulea	S	S
Black and White Warbler	Miniotilta varia	S	S
American Redtart	Setophaga ruticilia	S	S
Prothonotary Warbler	Protonotaria citrea	INC	S
Worm-eating Warbler	Helmitheros vermivorus	S	S
Ovenbird	Seiurus aurocapillus	S	S
Northern Waterthrush	Seiurus noveboracensis	S	S
Louisiana Waterthrush	Seiurus motacilla	S	S
Kentucky Warbler	Oporornis formosus	S	S
Connecticut Warbler	Oporornis agilis		S
Mourning Warbler	Oporornis philadelphia		S
Common Yellowthroat	Geothlypis trichas	S	S
Hooded Warbler	Wilsonia citrina	D	S
Wilson's Warbler	Wilsonia pusilla		S
Canada Warbler	Wilsonia canadensis	S	S
Yellow-breasted Chat	Icteria virens	D	S
Summer Tanager	Piranga rubra		S
Scarlet Tanager	Piranga olivacea	S	S
Northern Cardinal	Cardinalis cardinalis	INC	INC
Rose-breasted Grosbeak	Pheucticus ludovicianus	S	S
Blue Grosbeak	Guiraca caerulea	INC	S
Indigo Bunting	Passerina cyanea	S	S
Dickcissel	Spiza americana	EX	U
Rufous-sided Towhee	Pipilo erythrophthalmus	S	S
American Tree Sparrow	Spizella arborea		S
Chipping Sparrow	Spizella passerina	S	S
Field Sparrow	Spizella pusilla	S	S
Lark Sparrow	Chondestes grammacus		S
Savannah Sparrow	Passerculus sandwichensis	T	T
Ipswich Sparrow	Passerculus sandwichensis princeps	T	T
Grasshopper Sparrow	Ammodramus savannarum	T	T
Sharp-tailed Sparrow	Ammodramus caudacuta	S	S
Seaside Sparrow	Ammodramus maritima	S	S
Fox Sparrow	Passerella iliaca		S
Song Sparrow	Melospiza melodia	S	S
Lincoln's Sparrow	Melospiza lincolnii		S
Swamp Sparrow	Melospiza georgiana	S	S
White-throated Sparrow	Zonotrichia albicollis	S	S
White-crowned Sparrow	Zonotrichia leucophrys		INC
Dark-eyed Junco	Junco hyemalis	S	S
Lapland Longspur	Calcarius lapponicus		S
Snow Bunting	Plectophenax nivalis		S
Bobolink	Dolichonyx oryzivorus	T	T
Red-winged Blackbird	Agelaius phoeniceus	S	S
Eastern Meadowlark	Sturnella magna	D	S
Rusty Blackbird	Euphagus carolinus		S

Boat-tailed Grackle	Quiscalus major	INC	S
Common Grackle	Quiscalus quiscula	INC	S
Brown-headed Cowbird	Molothrus ater	INC	S
Orchard Oriole	Icterus spurius	S	S
Northern Oriole	Icterus galbula	S	S
Pine Grosbeak	Pinicola enucleator		S
Purple Finch	Carpodacus purpureus	S	S
House Finch	Carpodacus mexicanus	INC	S
Red Crossbill	Loxia curvirostra		S
White-winged Crossbill	Loxia leucoptera		S
Common Redpoll	Carduelis flammea		S
Pine Siskin	Carduelis pinus		S
American Goldfinch	Carduelis tristis	S	S
Evening Grosbeak	Hesperiphona vespertina		INC
House Sparrow	Passer domesticus	I	

APPENDIX C

Macroinvertebrates Taken in the Oceans and Bays in the Vicinity of Little Egg Inlet, New Jersey, from 1 January 1972, to 31 December 1975

Macroinvertebrates taken in the ocean and bays in the vicinity of Little Egg Inlet, New Jersey, from 1 January 1972 to 31 December 1975.*

MACROINVERTEBRATE SPECIES LIST

PHYLUM PORIFERA
- Class Demospongiae
  - Order Haplosclerida
    - Family Haliclonidae
      - *Haliclona* sp.
  - Order Poecilosclerida
    - Family Microcionidae
      - *Microciona prolifera* - redbeard sponge
  - Order Hadromerida
    - Family Clionidae
      - *Cliona celata* - boring sponge
      - *Cliona* sp.

PHYLUM CNIDARIA
- Class Hydrozoa - hydroid
  - Order Athecata
    - Family Tubulariidae
      - *Tubularia crocea* - pink-hearted hydroid
    - Family Margelopsidae
      - *Margelopsis gibbesi*
    - Family Hydractiniidae
      - *Hydractinia echinata* - spiny polymorphic hydroid
    - Family Bougainvilliidae
      - *Calyptospadix cerulea*
  - Order Thecata
    - Family Campanularidae
      - *Obelia commissuralis*
      - *Obelia flabellata*
      - *Obelia* sp.
    - Family Campanulinidae
      - *Lovenella* sp.
    - Family Aequoreidae
      - *Aequorea* sp.
    - Family Sertularidae
      - *Thuiaria argentea* - squirrel's tail hydroid
      - *Thuiaria* sp.
  - Order Trachymedusae
    - Family Geryonidae
      - *Liriope* sp.
- Class Scyphozoa - jellyfish
  - Order Semaeostomeae
    - Family Cyanidae
      - *Cyanea capillata* - lion's mane
  - Order Rhizostomeae
    - Family Rhisostomatidae
      - *Rhopilema verrilli*
- Class Anthozoa
  - Order Actiniaria - sea anemone
    - Tribe Athenaria
      - Athenaria "C"
    - Family Haloclavidae
      - *Haloclava producta*

Source: Milstein and Thomas, 1976

Tribe Thenaria
Family Sagartidae
Actinothoe modesta
Family Metridiidae
Metridium senile
Order Scleractinia
Astrangia danae - star coral
Order Ceriantharia
Cerianthus americanus - cerianth arian anemone

PHYLUM CTENOPHORA - comb jelly
Class Tentaculata
Order Cydippida
Family Pleurobrachiidae
Pleurobrachia pileus
Order Lobata
Family Mnemiidae
Mnemiopsis leidyi
Class Nuda
Order Beroida
Family Beroidae
Beroe sp.

PHYLUM PLATYHELMINTHES - flatworm
Order Trichladida
Family Bdellouridae
Bdelloura sp.
Order Polycladida
Family Stylochidae
Stylochus ellipticus
Stylochus zebra
Family Leptoplanidae
Euplana gracilis

PHYLUM NEMERTEA - ribbon worm
Class Anopla
Order Heteronemertea
Family Lineidae
Zygeupolia rubens
Cerebratulus lacteus
Class Enopla
Order Hoplonemertea
Family Amphiporidae
Zygonemertes virescens

PHYLUM ASCHELMINTHES
Class Gephyrea
Class Nematoda - round worm

PHYLUM CHAETOGNATHA - arrow worm
Sagitta elegans
Sagitta enflata
Sagitta sp.

PHYLUM BRYOZOA
Class Gymnolaemata
Order Ctenostomata
Family Alcyonidiidae
Alcyonidium polyoum
Family Nolellidae
Anguinella palmata

- Family Triticellidae
  - Triticella elongata
- Family Vesicularidae
  - Bowebankia gracilis
  - Amathia vidovici

Order Cyclostomata

- Family Tubuliporidae
  - Tubulipora sp.

Order Cheilostomata
- Suborder Anasca
  - Family Electridae
    - Electra hastingsae
  - Family Membraniporidae
    - Membraniopora tenuis
- Suborder Ascophora
  - Family Schizoporellidae
    - Schizoporella unicornis

PHYLUM MOLLUSCA
- Class Gastropoda
  - Subclass Prosobranchia
    - Order Mesogastropoda
      - Family Lacunicdae
        - Lacuna vincta - northern lacuna
      - Family Littorinidae
        - Littorina littorea - European periwinkle
      - Family Cerithiidae
        - Bittium alternatum - alternate bittium
      - Family Calyptraeidae
        - Crepidula fornicata - Atlantic slipper shell
        - Crepidula plana - Eastern white slipper shell
        - Crepidula convexa - convex slipper shell
      - Family Naticidae
        - Polinices duplicata - Atlantic moon snail
        - Polinices heros - northern moon snail
    - Order Neogastropoda
      - Family Muricidae
        - Urosalpinx cinereus - Atlantic oyster drill
        - Eupleura caudata - thick-lipped drill
      - Family Columbellidae
        - *Anachis avara - greedy dove shell
        - Mitrella lunata - lunar dove shell
      - Family Melongenidae
        - Busycon carica - knobbed whelk
        - Busycon canaliculatum - channeled whelk
      - Family Nassariidae
        - Nassarius vibex - Eastern nassa
        - Nassarius trivittatus - New England nassa
        - Ilyanassa obsoleta - Eastern mud nassa (mud snail)
  - Subclass Opisthobranchia
    - Order Cephalaspidea
      - Family Retusidae
        - Retusa obtusa - Arctic barrel-bubble
      - Family Atyidae
        - Haminoea solitaria

* Identified as Anachis translirata from 1970-1974.

Order Notaspidea

Family Pleurobranchiidae

Pleurobranchaea tarda

Order Tectibranchiata

Family Pyramidellidae (family of uncertain status)

Turbonilla interupta

Turbonilla sp.

Order Nudibranchia

Suborder Doridacea

Family Corambidae

Doridella obscura - obscurus corambe

Family Lamellidorididae

Acanthodoris pilosa - pilosa doris

Onchidorus fusca - dusky doris

Suborder Dendronotacea

Family Dendronotidae

Dendronotus frondosus - frond eolis

Family Dotonidae

Doto coronata - crowned sea slug

Suborder Aeolidacea

Family Cuthonidae

Tergipes despectus - johnston's balloon eolis

Family Facelinidae

Facelina bostoniensis - Boston facelina

Family Cratenidae

Cratena pilata

Family Aeolidiidae

Aeolidia papillosa - papillose eolis

Subclass Pulmonata

Order Basommatophora

Family Ellobiidae

Melampus bidentatus (family of uncertain status)

Class Bivalvia

Subclass Prionodesmata

Order Protobranchia

Family Solemyacidae

Solemya velum - awning clam

Family Nuculidae

Nucula proxima - nut clam

Nucula atacellana - cancellate nut clam

Family Nuculanidae

Yoldia limatula - file yoldia

Subclass Pteriomorphia

Order Prionodontida

Family Arcidae

Anadara ovalis - blood ark

Family Mytilidae

Mytilus edulis - blue mussel

Modiolus demissus - Atlantic ribbed mussel

Family Ostreidae

Crassostrea virginica - Eastern oyster

Family Pectinidae

Aequipecten irradians - bay scallop

Family Anomiidae

Anomia simplex - Atlantic jingle

Subclass Teleodesmata

Order Heterodontida

Family Astartidae

Astarte castanea - smooth astarte

Family Turtoniidae

Turtonia minuta

Family Cardiidae

Cerastoderma pinnulatum - northern dwarf cockle

Family Veneridae

Mercenaria mercenaria - northern quahog, hard clam

Gemma gemma - amethyst gem clam

Pitar morrhuana - morrhua venus

Family Petricolidae

Petricola pholadiformis - false angel wing

Family Mactridae

Spisula solidissima - Atlantic surf clam

Mulinia lateralis - little surf clam

Family Tellinidae

Tellina versicolor - DeKays' dwarf tellin

Tellina agilis - northern dwarf tellin

Tellina sp.

Family Donacidae

Donax fossor - fossor donax

Family Solecurtidae

Tagelus plebeius - stout tagelus

Family Solenidae

Ensis directus - Atlantic jackknife clam

Siliqua costata - Atlantic razor clam

Family Myidae

Mya arenaria - soft-shell clam

Family Pholadidae

Barnea truncata - fallen angel wing

Zirfaea crispata - great piddock

Family Teredinidae

Teredo navalis - shipworm

Family Pandoridae

Pandora sp.

Family Lyonsiidae

Lyonsia hyalina - glassy lyonsia

Class Cephalopoda

Subclass Coleoidae

Order Teuthidida

Family Loliginidae

Loligo pealei - Atlantic long-finned squid

Lolliguncula brevis - brief squid

Family Sepiolidae

Rossia tenera - Atlantic bob-tailed squid

PHYLUM ANNELIDA

Class Polychaeta - bristle worm

Order Phyllodocida

Family Phyllodocidae

Phyllodoce maculata

Phyllodoce arenae

Family Opheliidae

Ophelia bicornis
Ophelia denticulata
Travisia carnea

Family Spionidae

Spio filicornis
Spio setosa
Spio sp.
Scolecolepides viridis
Streblospio benedicti
Scolelepis squamata
Pygospio elegans
Prionospio sp.
Polydora ligni
Polydora websteri
Polydora ciliata
Polydora commensalis
Polydora socialis
Spiophanes bombyx
Dispio uncinata

Family Paraonidae

Paraonis fulgens
Aricidea jeffreysii

Family Chaetopteridae

Family Sabellariidae

Sabellaria vulgaris

Order Eunicida

Family Onuphidae

Onuphis opalina
Diopatra cuprea

Family Eunicidae

Marphysa sanguinea

Family Lumbrineridae

Lumbrineris acuta
Lumbrineris fragilis
Lumbrineris tenuis

Family Arabellidae

Arabella iricolor
Notocirrus spiniferus
Drilonereis longa
Drilonereis magna

Family Dorvilleidae

Protodorvillea sp. #1

Order Magelonida

Family Magelonidae

Magelona rosea

Paranaitis speciosa
Paranaitis kosteriensis
Mystides borealis
Eteone lactea
Eteone heteropoda
Eteone sp.
Eumida sanguinea
Eulalia viridis

Family Polynoidae
Antinoella sarsi
Lepidonotus squamatus
Lepidonotus sublevis
Harmothoe extenuata
Harmothoe sp.

Family Sigalionidae
Sigalion arenicola
Phloe minuta
Sthenelais boa
Sthenelais limicola
Leanira tetragona

Family Pisionidae
Pisione remota

Superfamily Glycera (includes Glyceridae and Goniadidae)

Family Glyceridae
Glycera capitata
Glycera americana
Glycera dibranchiata

Family Goniadidae
Goniada norvegica
Goniadella gracilis
Glycinde solitaria

Family Nephtyidae
Nephtys bucera
Nephtys incisa
Nephtys picta

Family Syllidae
Autolytus cornutus
Autolytus sp.
Parapionosyllis longicirrata
Syllis gracilis
Syllidae #1

Family Hesionidae
Podarke obscura
Microphthalmus sczelkowii
Microphthalmus aberrans

Family Nereidae
Nereis arenaceodonta
Nereis succinea

Order Capitellida

Family Capitellidae
Mediomastus ambiseta
Capitella capitata
Capitella sp.
Heteromastus filiformis
Notomastus luridis

Family Maldanidae
Clymenella torquata
Macroclymenella zonalis
Asychis elongata

Order Ariciida

Family Orbiniidae

Orbinia swani
Scoloplos robustus
Scoloplos fragilis
Scoloplos acutus

Order Cirratulida

Family Cirratulidae

Cirratulus grandis
Tharyx acutus

Order Terebellida

Family Pectinariidae

Pectinaria gouldii

Family Ampharetidae

Ampharete arctica
Asabellides oculata
Hypaniola grayi

Family Terebellidae

Amphitrite ornata
Pista sp.
Polycirrus eximius
Polycirrus sp.

Order Flabelligerida

Family Flabelligeridae

Pherusa affinis

Order Sabellida

Family Sabellidae

Sabella microphthalma
Potamilla neglecta

Family Serpulidae

Hydroides dianthus

Class Oligochaeta - aquatic earthworm

Family Tubificidae

Class Hirudinea - leeche

Family Piscicolidae

Branchelion ravenelli
Ichthyobdella rapax
Myzobdella sp.
Trachelobdella sp.

PHYLUM ARTHROPODA

Subphylum Pycnogonida

Class Pantopoda

Family Phoxichilidiidae

Anoplodactylus lentus - sea spider

Subphylum Chelicerata

Class Merostomata

Order Xiphosurida

Family Limulidae

Limulus polyphemus - horseshoe crab

Subphylum Mandibulata

Class Crustacea

Subclass Ostracoda

Subclass Copepoda

Order Calanoida

- *Anomalocera pattersoni*

Order Caligoida

Order Harpacticoida

Subclass Cirripedia

- Order Thoracica
  - Suborder Lepadomorpha
    - Family Lepadidae - gooseneck barnacle
      - *Lepas anatifera*
  - Suborder Balanomorpha - acorn barnacle
    - Family Balanidae
      - *Balanus balanoides* - rock barnacle
      - *Balanus eburneus*
      - *Balanus* sp.

Subclass Malacostraca

- Superorder Hoplocarida
  - Order Stomatopoda - mantis shrimp
    - Family Squillidae
      - *Squilla empusa*
    - Family Lysiosquillidae
      - *Nannosquilla grayi*
- Superorder Peracarida
  - Order Cumacea
    - Family Bodotriidae
      - *Cyclaspis varians*
      - *Leptocuma minor*
    - Family Leuconidae
      - *Leucon americanus*
    - Family Diastylidae
      - *Diastylus polita*
      - *Oxyurostylis smithi*
  - Order Tanaidacea
    - Family Paratanaidae
      - *Leptognatha caeca*
      - *Leptochelia savignyi*
  - Order Isopoda
    - Suborder Anthuridea
      - Family Anthuridae
        - *Cyathura polita*
    - Suborder Flabellifera
      - Family Cirolanidae
        - *Cirolana concharum*
        - *Cirolana polita*
      - Family Cymothoidae
        - *Olencira praegustator*
        - *Lironeca ovalis*
      - Family Limnoridae
        - *Limnoria lignorum*
    - Suborder Valvifera
      - Family Idoteidae
        - *Chiridotea coeca*
        - *Chiridotea tuftsi*
        - *Chiridotea nigrescens*
        - *Idotea metallica*
        - *Idotea baltica*
        - *Edotea triloba*
        - *Erichsonella filiformis*

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Family Bopyridae

Probopyrus pandalicola

Order Amphipoda (families are listed alphabetically)

Suborder Hyperiidea

Suborder Gammaridae

Family Ampeliscidae

Ampelisca abdita
Ampelisca vadorum
Ampelisca verrilli

Family Ampithoidae

Ampithoe longimana

Family Aoridae

Leptocheirus plumulosus
Microdeutopus gryllotalpa
Microdeutopus sp.
Pseudunciola obliquua
Unciola dissimilis
Unciola irrorata
Unciola serrata

Family Bateidae

Batea catharinensis

Family Calliopiopiidae

Calliopius laeviusculus

Family Corophiidae

Cerapus tubularis
Corophium tuberculatum
Erichthonius brasiliensis
Erichthonius rubricornis

Family Gammaridae

Gammarus annulatus
Gammarus lawrencianus
Gammarus mucronatus
Gammarus oceanicus

Family Haustoriidae

Acanthohaustorius intermedius
Acanthohaustorius millsi
Acanthohaustorius shoemakeri
Haustorius canadensis
Neohaustorius biarticulatus
Neohaustorius schmitzi
Parahaustorius attenuatus
Parahaustorius holmesi
Parahaustorius longimerus
Protohaustorius deichmannae
Protohaustorius wigleyi
Amphiporeia virginiana
Bathyporeia quoddyensis

Family Hyalidae

Hyale plumulosa

Family Ischyroceridae

Jassa falcata

Family Lysianassidae

Anonyx sarsi
Lysianopsis alba
Orchomenella pinguis
Psammonyx nobilis

Family Melitidae

Elasmopus levis

Melita nitida

Family Oedicerotidae

Monoculodes edwardsi

Synchelidium americanum

Family Photidae

Microprotopus raneyi

Family Phoxocephalidae

Paraphoxus spinosus

Phoxocephalus holbolli

Trichophoxus epistomus

Family Pleustidae

Pleusymtes glaber

Family Pontogeneiidae

Pontogeneia inermis

Family Stenothoidae

Parametopella cypris

Proboloides holmesi

Stenothoe minuta

Order Caprellidea

Family Caprellidae

Aeginina longicornis

Caprella equilibra

Caprella penantis

Caprella unica

Order Mysidacea

Mysidopsis bigelowi

Neomysis americana

Heteromysis formosa

Superorder Eucarida

Order Decapoda

Suborder Natantia

Infraorder Penaeidea

Family Penaeidae

Penaeus setiferus - white shrimp

Penaeus aztecus - brown shrimp

Infraorder Caridea

Family Palaemonidae - grass shrimp

Palaemonetes vulgaris

Palaemonetes pugio

Family Hippolytidae

Hippolyte pleuracantha

Hippolysmata wurdemanni

Family Pandalidae

Dichelopandalus leptocerus

Family Crangonidae

Crangon septemspinosa - sand shrimp

Suborder Reptania

Infraorder Astacidea

Family Nephropsidae

Homarus americanus - American lobster

Infraorder Anomura

Superfamily Thalassinoidea

Family Upogebiidae

Upogebia affinis - mud shrimp

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Superfamily Paguroidea

Family Paguridae - hermit crab

Pagurus acadianus

Pagurus longicarpus - long-armed hermit crab

Pagurus pollicaris - big hermit crab

Superfamily Hippoidea

Family Hippidae

Emerita talpoida - mole crab

Infraorder Brachyura - crab

Family Majidae

Libinia emarginata - spider crab

Libinia dubia - spider crab

Family Cancridae

Cancer irroratus - rock crab

Cancer borealis - northern rock crab, jonah crab

Family Portunidae

Carcinus maenas - green crab

Ovalipes ocellatus - lady crab

Portunus gibbesi

Portunus spinimanus

Callinectes sapidus - blue crab

Callinectes similis - lesser blue crab

Arenaeus cribrarius - speckled crab

Cronius ruber

Family Xanthidae

Panopeus herbstii

* *Neopanope texana*

Eurypanopeus depressus - flat mud crab

Rhithropanopeus harrisii

Family Pinnotheridae

Pinnotheres maculatus - mussel crab

Dissodactylus mellitae

Family Ocypodidae

Uca minax

Uca pugnax - fiddler crab

PHYLUM ECHINODERMATA

Class Holothuroidea

Order Apodida

Family Synaptidae

Leptosynapta inhaerens - sea cucumber

Class Echinoidea

Order Arbacioida

Family Arbaciidae

Arbacia punctulata - purple sea urchin

Order Clypeasteroida

Family Echinarachnidae

Echinarachnius parma - sand dollar

Order Spatangoidea

Family Spatangidae

Echinocardium cordatum

Class Stelleroidea

Subclass Asteroidea

Order Forcipulatida

Family Asteriidae

Asterias forbesii - starfish

Asterias vulgaris - northern starfish

* Referred to as *Neopanope sayi* in Williams (1974)

PHYLUM HEMICHORDATA

Family Harrimaniidae

Saccoglossus kowalevskii - acorn worm

PHYLUM CHORDATA

Class Ascidiacea - sessile tunicate

Order Enterogona

Suborder Phlebobranchia

Family Perophoridae

Perophora viridis - green bead

Order Pleurogona

Suborder Stolidobranchiata

Family Molgulidae

Molgula manhattensis - sea grape

MISCELLANEOUS LIFE STAGES

Hydrozoa: embryonated eggs
Scyphozoa: strobila
Polinices sp.: eggs
Busycon canaliculatum: egg case
Busycon sp.: egg case
Nassarius trivittatus: eggs
Loliginidae: eggs
Mytilus edulis: spat
Decapoda: larvae
Palaemonetes sp.: zoea
Caridea: larvae, zoea

Crangon septemspinosa: zoea, subadult
Emerita talpoida: zoea
Anomura: zoea
Xanthidae: zoea
Neopanope texana: zoea
Cancer irroratus: zoea, megalopa, subadult
Callinectes sapidus: zoea, megalopa
Pinnixa sp.: zoea
Brachyura: zoea
Crustacea: zoea
Asterias forbesii: brachiolaria

* The scientific names are arranged in phylogenetic order Gosner(1971) except for the amphipods which follow Bousfield (1973).

APPENDIX D

Results of a 1989 Colonial Nesting Waterbird Survey in the Reeds Bay/Absecon Bay Area

Table D-1. Number of Individuals of 14 Species of Colonial Nesting Waterbirds Recorded in 39 Colonies on Islands in the Reeds Bay/Absecon Bay Area, New Jersey, During a 1989 Survey (Jenkins et al., 1989).

Colony Number	Species			
	Little Blue Heron	Tri-Colored Heron	Black-Crowned Night Heron	Yellow-Crowned Night Heron
6249H	4	2	5	0
6251	8	4	1	0
6351H	0	40	2	0
6352H	21	28	10	0
Subtotal	33	74	18	0

Colony Number	Great Egret	Snowy Egret	Cattle Egret	Glossy Ibis
6045H	9	105	0	0
6249H	0	70	0	7
6251	0	45	0	0
6352	20	125	15	45
Subtotal	29	345	15	52

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Table D-1. (Continued)

Colony Number	Common Tern	Forster's Tern
6047	68	0
6048	42	0
6147	2	15
6148	26	0
6149	0	15
6150	455	41
6247	2	25
6248	140	42
6251	12	0
6253	95	0
6348	0	55
6349	0	56
6449S	80	28
6451N	19	0
6451S	37	0
6453	243	0
6552	8	0
6555	85	0
Subtotal	1,314	287

Table D-1. (Continued)

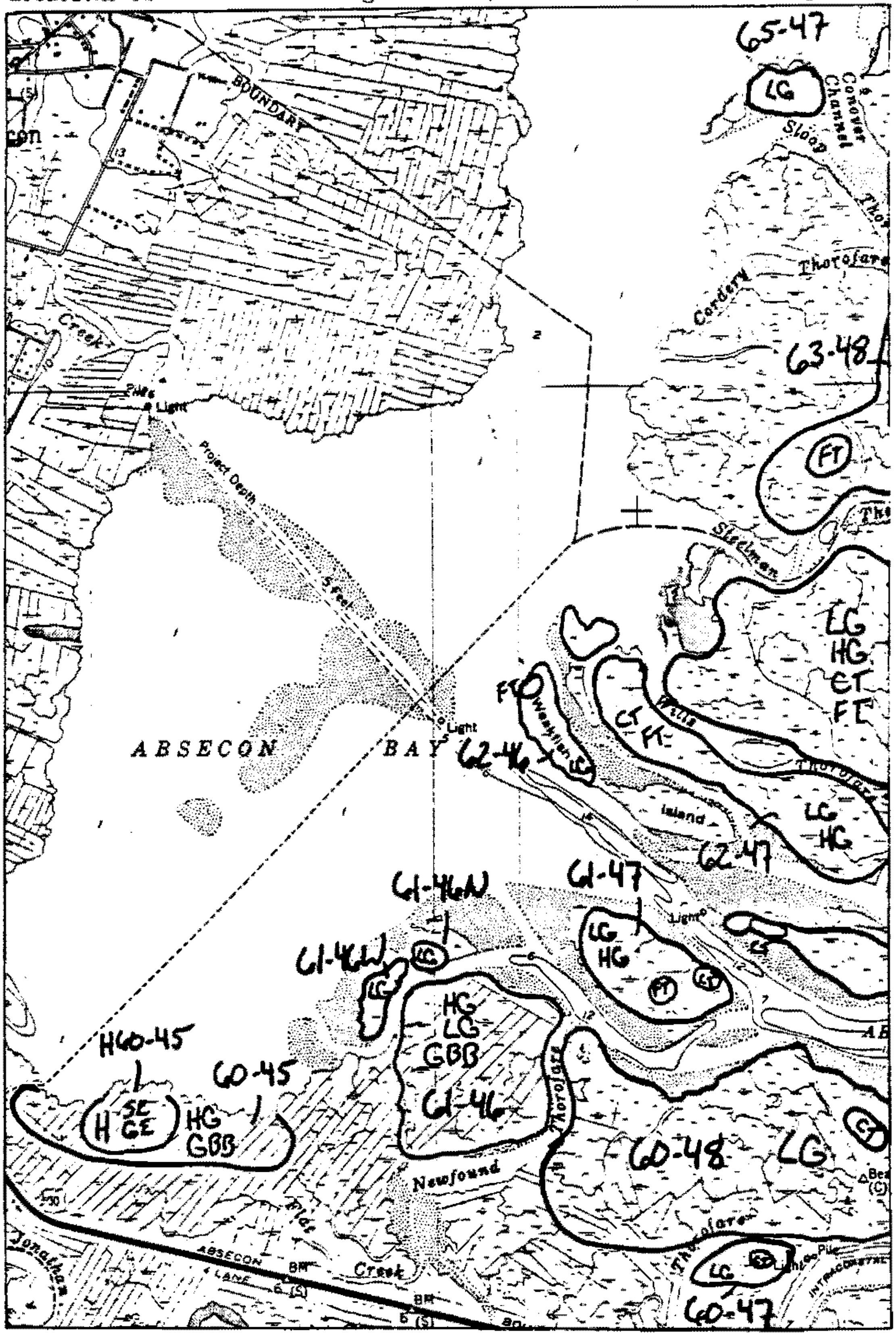
Colony Number	Herring Gull	Great Black-Backed Gull	Laughing Gull
6045	87	4	0
6047	0	0	95
6048	3	1	375
6049	0	0	65
6146	107	11	720
6146N	0	0	15
6146W	0	0	220
6147	2	0	940
6148	9	0	700
6149	0	0	85
6150	1	1	190
6151	28	1	0
6247	1	0	880
6248	3	0	670
6249	13	0	0
6251	29	1	240
6252	0	0	55
6348	0	0	55
6349	63	0	270
6351	99	3	85
6352	160	4	0
6449S	2	0	363
6450	2	0	0
6451N	1	0	10
6451S	7	1	65
6453	0	3	295
6547	0	0	15
6555	0	1	210
Subtotal	617	31	6,618

APPENDIX D (Continued)
Results of a 1989 Colonial Nesting Waterbird Survey
in the Reeds Bay/Absecon Bay Area

Maps of the Study Area Showing Locations of
Colonial Nesting Waterbirds

(Source: Jenkins et al., 1989)

Locations of Waterbird Nesting Colonies, Oceanville, N.J. Quadrangle



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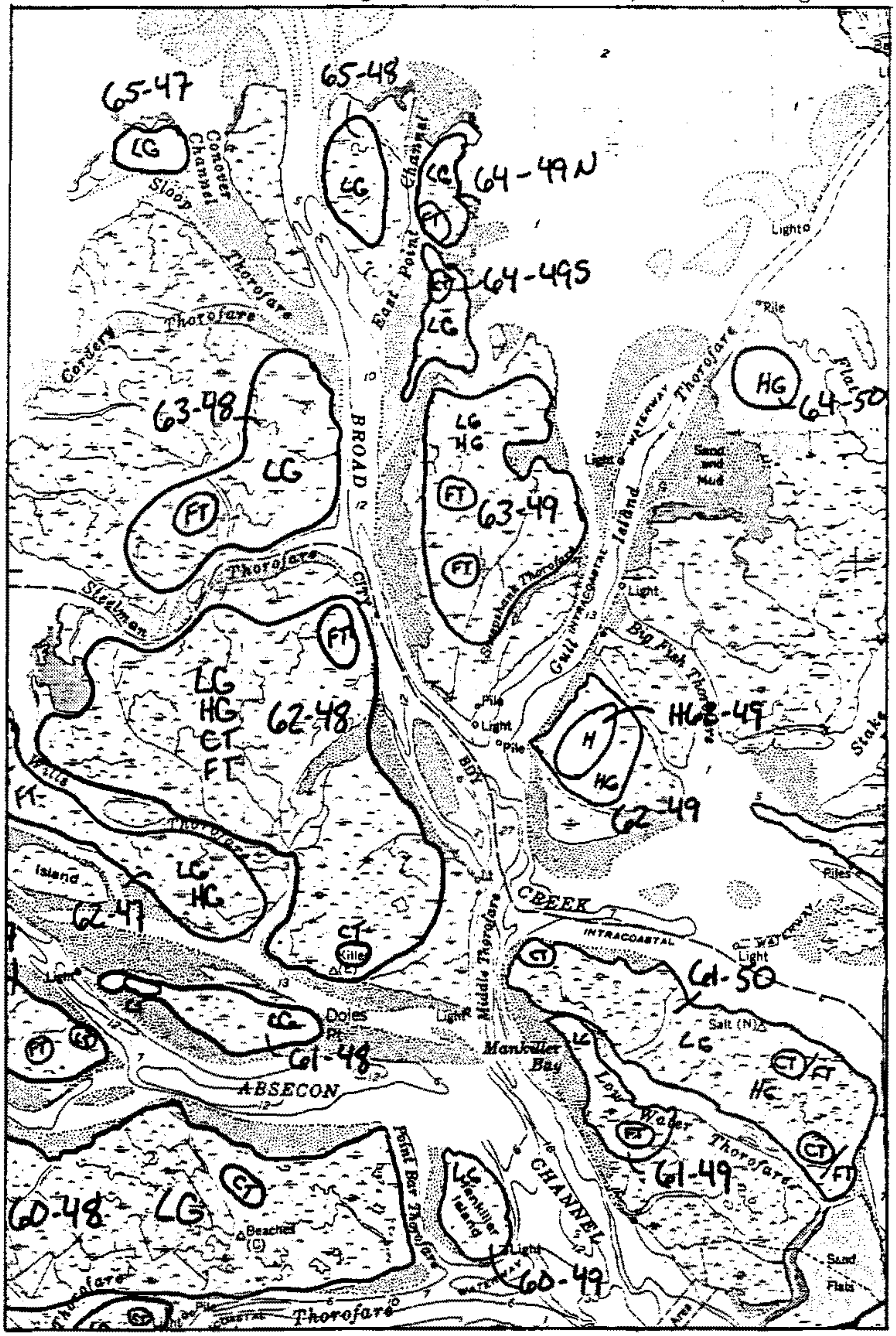
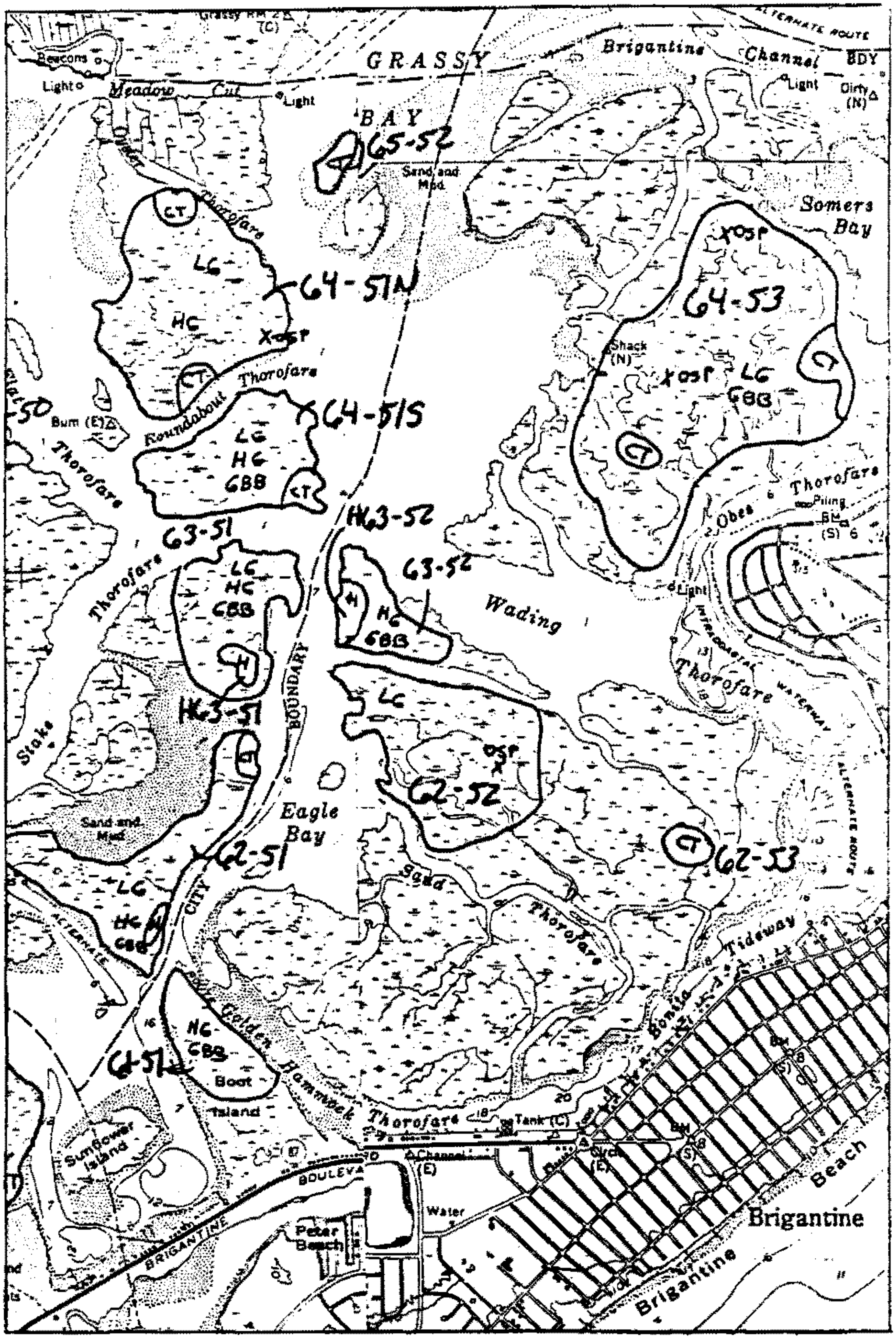
Locations of Waterbird Nesting Colonies, Oceanville, N.J. Quadrangle



Location of Waterbird Nesting Colonies, Oceanville, N.J. and Brigantine Inlet, N.J. Quadrangles



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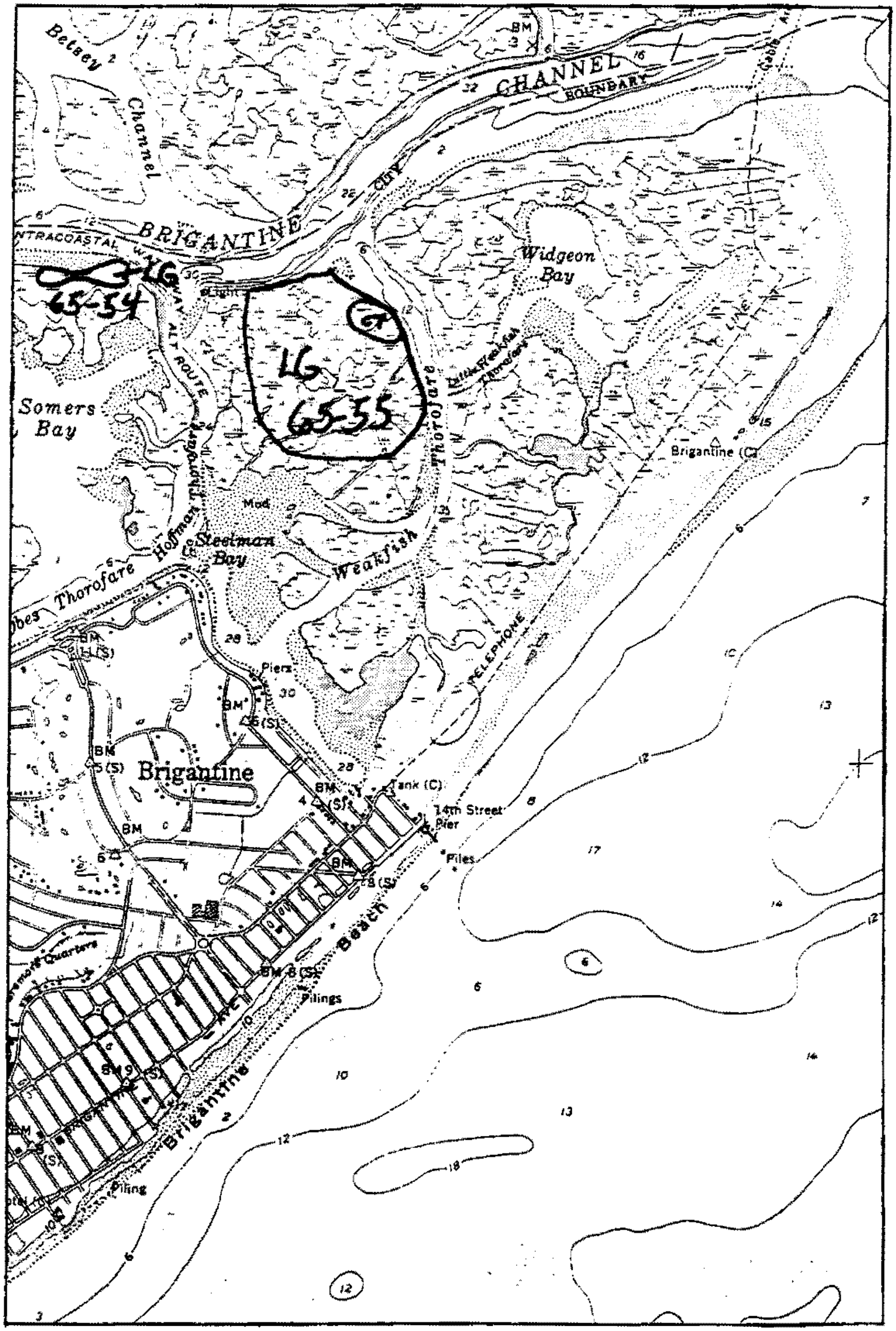
Locations of Waterbird Nesting Colonies, Brigantine Inlet, N.J. Quadrangle



APPENDIX E
Occurrences on Oceanville USGS Quadrangle Map,
Rare Species and Natural Communities Presently Recorded
in the New Jersey Natural Heritage Database

NATURAL LANDS MANAGEMENT

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

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This [illegible] provide a letter of interpretation or a statement add[illegible] classification of wetlands as defined by the Freshwater [illegible]. Requests for such determinations should be sent to [illegible] of Coastal Resources, Bureau of Freshwater Wetland[illegible] NJ 08625.

[illegible]ded by this database may not be published withou[illegible] the written permission of the Office of Natural Lands [illegible]. In addition, the Natural Heritage Program must be credit[illegible] information source in any publication of data.

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OCCURRENCES ON OCEANVILLE USGS QUADRANGLE MAP
RARE SPECIES AND NATURAL COMMUNITIES PRESENTLY RECORDED IN
THE NEW JERSEY NATURAL HERITAGE DATABASE

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK	DATE OBSERVED	IDENTI-FICATION
AMMODRAMUS SAVANNARUM	GRASSHOPPER SPARROW		LT	G4	S3	1985-SUMMR	Y
ARETHUSA BULBOSA	DRAGON MOUTH			G4	S2	198?-??-??	Y
ASCLEPIAS RUBRA	RED MILKWEED		LP	G4G5	S2	198?-??-??	Y
BALD EAGLE WINTERING SITE	BALD EAGLE WINTERING SITE			G?	S?	1984-01-??	Y
BARTRAMIA LONGICAUDA	UPLAND SANDPIPER		LE	G5	S1	1977-??-??	Y
CHARADRIUS MELODUS	PIPING PLOVER	LELT	LE	G2	S1	1987-08-??	Y
CISTOTHORUS PLATENSIS	SEDGE WREN		LE	G5	SH	197?-??-??	Y
CLEMMYS INSCULPTA	WOOD TURTLE		LT	G5	S4	1945-07-03	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1986-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1983-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1979-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1977-06-??	Y
COASTAL HERON ROOKERY	COASTAL HERON ROOKERY			GU	S3	1985-06-??	Y
FALCO PEREGRINUS	PEREGRINE FALCON	LE	LE	G3	S2	1986-SUMMR	Y
FALCO PEREGRINUS	PEREGRINE FALCON	LE	LE	G3	S2	1985-SUMMR	Y
HYLA ANDERSONII	PINE BARRENS TREEFROG	C2	LE	G4	S4	1981-06-23	Y
HYLA ANDERSONII	PINE BARRENS TREEFROG	C2	LE	G4	S4	1979-06-10	Y
HYLA ANDERSONII	PINE BARRENS TREEFROG	C2	LE	G4	S4	1987-SUMMR	Y
MIGRATORY SHOREBIRD CONCENTRATION SITE	MIGRATORY SHOREBIRD CONCENTRATION SITE			G?	S?	1984-??-??	
NYCTICORAX VIOLACEUS	YELLOW-CROWNED NIGHT-HERON		LT	G5	S2	1985-06-??	Y
NYCTICORAX VIOLACEUS	YELLOW-CROWNED NIGHT-HERON		LT	G5	S2	1985-06-??	Y
NYCTICORAX VIOLACEUS	YELLOW-CROWNED NIGHT-HERON		LT	G5	S2	1977-06-??	Y
PITUOPHIS MELANOLEUCUS	PINE SNAKE		LT	G5	S3	1979-08-29	Y
PLATANTHERA CRISTATA	CRESTED YELLOW ORCHID		LP	G5	S3	198?-??-??	Y
PODILYMBUS PODICEPS	PIED-BILLED GREBE		LE	G5	S1	1981-??-??	Y
RYNCHOPS NIGER	BLACK SKIMMER		LE	G5	S2	1978-??-??	Y

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OCCURRENCES ON OCEANVILLE USGS QUADRANGLE MAP
RARE SPECIES AND NATURAL COMMUNITIES PRESENTLY RECORDED IN
THE NEW JERSEY NATURAL HERITAGE DATABASE

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK	DATE OBSERVED	IDENTI-FICATION
SCHIZAEA PUSILLA	CURLY GRASS FERN	C2	LP	G3	S3	1908-??-??	Y
SCHIZAEA PUSILLA	CURLY GRASS FERN	C2	LP	G3	S3	198?-??-??	Y
SPIRANTHES ODORATA	FRAGRANT LADIES'-TRESSES			G5	S1	1985-??-??	Y
STERNA ANTILLARUM	LEAST TERN	LE	LE	G4	S2	1986-SUMMR	Y
STERNA ANTILLARUM	LEAST TERN	LE	LE	G4	S2	1984-SUMMR	Y
STERNA ANTILLARUM	LEAST TERN	LE	LE	G4	S2	1984-??-??	Y
STERNA ANTILLARUM	LEAST TERN	LE	LE	G4	S2	1984-??-??	Y
STRIX VARIA	BARRED OWL		LT	G5	S3	1979-09-06	Y
UTRICULARIA PURPUREA	PURPLE BLADDERWORT		LP	G5	S3	198?-??-??	Y

APPENDIX F

New Jersey Natural Heritage Program, Potential Threatened and Endangered Vertebrate Species in Atlantic County

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

The quantity and quality of data collected by the Natural Heritage Program is dependent on the research and observations of many individuals and organizations. Not all of this information is the result of comprehensive or site-specific field surveys. Some natural areas in New Jersey have never been thoroughly surveyed. As a result, new locations for plant and animal species are continuously added to the data base. Since data acquisition is a dynamic, ongoing process, this Office cannot provide a definitive statement on the presence, absence, or condition of biological elements in any part of New Jersey. Information supplied by the Natural Heritage Program summarizes existing data known to the program at the time of the request regarding the biological elements or locations in question. The information should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The attached data is provided as one source of information to assist others in the preservation of natural diversity.

This office cannot provide a letter of interpretation or a statement addressing the classification of wetlands as defined by the Freshwater Wetlands Act. Requests for such determination should be sent to the DEP, Division of Coastal Resources, Bureau of Freshwater Wetlands, CN 401, Trenton, NJ 08625.

Information provided by this database may not be published without first obtaining the written permission of the Office of Natural Lands Management. In addition, the Natural Heritage Program must be credited as an information source in any publication of data.

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NEW JERSEY NATURAL HERITAGE PROGRAM
POTENTIAL THREATENED AND ENDANGERED VERTEBRATE SPECIES
IN ATLANTIC COUNTY

AMERICAN BITTERN BOTAURUS LENTIGINOSUS	FEDERAL STATUS: STATE STATUS: LT	COUNTY OCCURRENCE: Y

HABITAT COMMENTS
Fresh water bogs, swamps, wet fields, cattail and bulrush marshes, brackish and saltwater marshes and meadows.

BALD EAGLE HALIAEETUS LEUCOCEPHALUS	FEDERAL STATUS: LELT STATE STATUS: LE	COUNTY OCCURRENCE: W*

HABITAT COMMENTS
Primarily near seacoasts, rivers, and large lakes.

BARRED OWL STRIX VARIA	FEDERAL STATUS: STATE STATUS: LT	COUNTY OCCURRENCE: Y

HABITAT COMMENTS
Dense woodland and forest (conif. or hardwood), swamps, wooded river valleys, cabbage palm-live oak hammocks, especially where bordering streams, marshes, and meadows

BLACK RAIL LATTERALLUS JAMAICENSIS	FEDERAL STATUS: STATE STATUS: LT	COUNTY OCCURRENCE: B

HABITAT COMMENTS
Salt, brackish, and freshwater marshes, wet meadows, and grassy swamps.

BLACK SKIMMER RYNCHOPS NIGER	FEDERAL STATUS: STATE STATUS: LE	COUNTY OCCURRENCE: B

HABITAT COMMENTS
Primarily coastal waters, including bays, estuaries, lagoons and mudflats in migration and winter.

BOG TURTLE CLEMMYS MUHLENBERGII	FEDERAL STATUS: C2 STATE STATUS: LE	COUNTY OCCURRENCE: Y

HABITAT COMMENTS
Slow, shallow rivulets of sphagnum bogs, swamps, and marshy meadows; sea level to 1200 m in Appalachians. Commonly basks on tussocks in morning in spring and early summer. Hibernates in subterreanean rivulet or seepage area.

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BROOK TROUT — FEDERAL STATUS: — COUNTY
SALVELINUS FONTINALIS — STATE STATUS: LT — OCCURRENCE: Y

BROOK TROUT	FEDERAL STATUS:	COUNTY
SALVELINUS FONTINALIS	STATE STATUS: LT	OCCURRENCE: Y

HABITAT COMMENTS
Clear cool well-oxygenated streams and lakes. May move from streams into lakes or sea to avoid high temps. in summer.

COOPER'S HAWK	FEDERAL STATUS:	COUNTY
ACCIPITER COOPERII	STATE STATUS: LE	OCCURRENCE: W*

HABITAT COMMENTS
Primarily mature forest, either broadleaf or coniferous, mostly the former; also open woodland and forest edge.

CORN SNAKE	FEDERAL STATUS:	COUNTY
ELAPHE GUTTATA	STATE STATUS: LE	OCCURRENCE: Y

HABITAT COMMENTS
Rocky hillsides, meadows, along stream courses and river bottoms, canyons and arroyos, barnyards, abandoned houses and ranch buildings, near springs, in caves, wooded areas. Terrestrial, arboreal, and subterranean. Stays hidden by day.

GRASSHOPPER SPARROW	FEDERAL STATUS:	COUNTY
AMMODRAMUS SAVANNARUM	STATE STATUS: LT	OCCURRENCE: Y

HABITAT COMMENTS
Prairie, old fields, open grasslands, cultivated fields, savanna.

GREAT BLUE HERON	FEDERAL STATUS:	COUNTY
ARDEA HERODIAS	STATE STATUS: LT	OCCURRENCE: Y

HABITAT COMMENTS
Freshwater and brackish marshes, along lakes, rivers, bays, lagoons, ocean beaches, mangroves, fields, and meadows.

LEAST TERN	FEDERAL STATUS:	COUNTY
STERNA ANTILLARUM	STATE STATUS: LE	OCCURRENCE: B

HABITAT COMMENTS
Seacoasts, beaches, bays, estuaries, lagoons, lakes, and rivers.

LOGGERHEAD SHRIKE	FEDERAL STATUS: C2	COUNTY
LANIUS LUDOVICIANUS MIGRANS	STATE STATUS: LE	OCCURRENCE: W

HABITAT COMMENTS
"Open country with scattered trees and shrubs, savanna, desert scrub and, occasionally, open woodland, often found on poles, wires or fenceposts (Tropical to Temperate zones)."

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MERLIN — FEDERAL STATUS: — COUNTY
FALCO COLUMBARIUS — STATE STATUS: LT — OCCURRENCE: W

HABITAT COMMENTS
During the breeding season inhabits coniferous or deciduous open woodlands, wooded prairies. At other times of the year found in a wide variety of habitats including: marshes and deserts, seacoasts, open woodlands, fields, etc.

MUD SALAMANDER — FEDERAL STATUS: — COUNTY
PSEUDOTRITON MONTANUS — STATE STATUS: LT — OCCURRENCE: ?

HABITAT COMMENTS
Muddy springs, slow floodplain streams, and swamps along slow streams. Nonlarval forms usually found beneath logs and rocks, in decaying vegetation, and in muddy stream-bank burrows. Occasionally disperses from wet muddy areas.

NORTHERN HARRIER — FEDERAL STATUS: — COUNTY
CIRCUS CYANEUS — STATE STATUS: LE — OCCURRENCE: Y

HABITAT COMMENTS
Marshes, meadows, grasslands, and cultivated fields. Perches on ground or on stumps or posts.

OSPREY — FEDERAL STATUS: — COUNTY
PANDION HALIAETUS — STATE STATUS: LT — OCCURRENCE: B

HABITAT COMMENTS
Primarily along rivers, lakes, and seacoasts, occurring widely in migration, often crossing land between bodies of water.

PEREGRINE FALCON — FEDERAL STATUS: LE — COUNTY
FALCO PEREGRINUS — STATE STATUS: LE — OCCURRENCE: Y

HABITAT COMMENTS
"A variety of open situations from tundra, moorlands, steppe and seacoasts, especially where there are suitable nesting cliffs, to high mountains, more open forested regions, and even human population centers...".

PIED-BILLED GREBE — FEDERAL STATUS: — COUNTY
PODILYMBUS PODICEPS — STATE STATUS: LE — OCCURRENCE: Y

HABITAT COMMENTS
Lakes, ponds, sluggish streams, and marshes; in migration and in winter also in brackish bays and estuaries.

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PINE BARRENS TREEFROG — FEDERAL STATUS: C2 — COUNTY
<u>HYLA</u> <u>ANDERSONII</u> — STATE STATUS: LE — OCCURRENCE: Y

HABITAT COMMENTS
Streams, ponds, cranberry bogs, and other wetland habitats. Post-breeding habitat the woodlands bordering these areas.

PINE SNAKE — FEDERAL STATUS: — COUNTY
<u>PITUOPHIS</u> <u>MELANOLEUCUS</u> — STATE STATUS: LT — OCCURRENCE: Y

HABITAT COMMENTS
Lowlands to mountains; desert, prairie, brushland, woodland, open coniferous forest, farmland, marshes. Terrestrial, fossorial, and arboreal. Underground in cold weather.

PIPING PLOVER — FEDERAL STATUS: LELT — COUNTY
<u>CHARADRIUS</u> <u>MELODUS</u> — STATE STATUS: LE — OCCURRENCE: B

HABITAT COMMENTS
Sandy beaches, especially where scattered grass tufts are present, sparsely vegetated shores and islands of shallow lakes, ponds, and impoundments. In migration and winter also mudflats, flooded fields.

RED-HEADED WOODPECKER — FEDERAL STATUS: — COUNTY
<u>MELANERPES</u> <u>ERYTHROCEPHALUS</u> — STATE STATUS: LT — OCCURRENCE: Y

HABITAT COMMENTS
Open woodland, especially with beech or oak, open situations with scattered trees, parks, cultivated areas and gardens.

RED-SHOULDERED HAWK — FEDERAL STATUS: — COUNTY
<u>BUTEO</u> <u>LINEATUS</u> — STATE STATUS: LT — OCCURRENCE: W*

HABITAT COMMENTS
Moist and riverine forest, and in e. N. Am. in wooded swamps, foraging in forest edge and open woodland.

ROSEATE TERN — FEDERAL STATUS: PEPT — COUNTY
<u>STERNA</u> <u>DOUGALLII</u> — STATE STATUS: LE — OCCURRENCE: ?

HABITAT COMMENTS
Seacoasts, bays, estuaries.

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SAVANNAH SPARROW — FEDERAL STATUS: — COUNTY
<u>PASSERCULUS</u> <u>SANDWICHENSIS</u> — STATE STATUS: LT — OCCURRENCE: W*

SAVANNAH SPARROW	FEDERAL STATUS:	COUNTY
PASSERCULUS SANDWICHENSIS	STATE STATUS: LT	OCCURRENCE: W*

HABITAT COMMENTS
"Open areas, especially grasslands, tundra, meadows, bogs, farmlands, grassy areas with scattered bushes, and marshes, including salt marshes in the BELDINGI and ROSTRATUS groups (Subtropical and Temperate zones)".

SEDGE WREN	FEDERAL STATUS:	COUNTY
CISTOTHORUS PLATENSIS	STATE STATUS: LE	OCCURRENCE: ?

HABITAT COMMENTS
Grasslands and savanna, especially where wet or boggy, sedge marshes, locally in dry cultivated grainfields. In migration and winter also in brushy grasslands.

SHORT-EARED OWL	FEDERAL STATUS:	COUNTY
ASIO FLAMMEUS	STATE STATUS: LE/S	OCCURRENCE: W*

HABITAT COMMENTS
Open country, including prairie, meadows, tundra, moorlands, marshes, savanna, dunes, fields, and open woodland. Roosts by day on ground or on low open perches.

TIGER SALAMANDER	FEDERAL STATUS:	COUNTY
AMBYSTOMA TIGRINUM	STATE STATUS: LE	OCCURRENCE: Y

HABITAT COMMENTS
Found in virtually any habitat, providing there is a body of water nearby suitable for breeding. Terrestrial adults primarily subterranean.

TIMBER RATTLESNAKE	FEDERAL STATUS:	COUNTY
CROTALUS HORRIDUS	STATE STATUS: LE	OCCURRENCE: ?

HABITAT COMMENTS
Wooded rocky hillsides in north; swampy areas, canebrake thickets, and floodplains in south. Near streams in late summer in some areas. Often hibernates in burrows and crevices of rock outcroppings.

UPLAND SANDPIPER	FEDERAL STATUS:	COUNTY
BARTRAMIA LONGICAUDA	STATE STATUS: LE	OCCURRENCE: Y

HABITAT COMMENTS
Grasslands, especially prairies, dry meadows, pastures, and (in Alaska) scattered woodlands at timberline; very rarely in migration along shores and mudflats.

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VESPER SPARROW	FEDERAL STATUS:	COUNTY
POOECETES GRAMINEUS	STATE STATUS: LE	OCCURRENCE: Y

HABITAT COMMENTS
"Plains, prairie, dry shrublands, savanna, weedy pastures, fields, sagebrush, arid scrub and woodland clearings".

YELLOW-CROWNED NIGHT-HERON	FEDERAL STATUS:	COUNTY
NYCTICORAX VIOLACEUS	STATE STATUS: LT	OCCURRENCE: B

HABITAT COMMENTS
Marshes, swamps, lakes, lagoons, and mangroves.

PLANNING AID REPORT

BRIGANTINE INLET TO GREAT EGG HARBOR INLET FEASIBILITY STUDY
ATLANTIC COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

January 1995

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-94/44

January 26, 1995

Lt. Colonel Robert P. Magnifico
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Magnifico:

The U.S. Fish and Wildlife Service (Service) has reviewed the U.S Army Corps of Engineers, Philadelphia District (District) Draft Report of the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey: Benthic Animal Assessment of Potential Borrow Source, dated December 1994. This report on benthic resources was produced by Battelle Ocean Sciences. The Service's review of the benthic report, the findings being presented in this Planning Aid Report, was prepared pursuant to the scope-of-work and Fiscal Year-1994 interagency agreement between the District and the Service.

Pursuant to the interagency agreement, the Service also reviewed the Service's previous Planning Aid Report for the *Brigantine Inlet to Absecon Inlet, Brigantine Inlet to Great Egg Harbor Inlet Reach, New Jersey Shore Protection Reconnaissance Study*, dated August 1991. The purpose of the Service's review of the 1991 PAR was to update the information presented in the PAR and to provide additional information relevant to the Townsends Inlet to Cape May Inlet portion of the District's New Jersey Shore Protection study area.

The comments in this Planning Aid Report are provided as technical assistance and do not constitute the report of the Secretary of Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*). These comments do not preclude separate review and comments by the Service on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

If you have any questions on this Planning Aid Report, please contact Eric Schrading of my staff.

Sincerely,

Clifford G. Day
Supervisor

PLANNING AID REPORT

BRIGANTINE INLET TO GREAT EGG HARBOR INLET FEASIBILITY STUDY
ATLANTIC COUNTY, NEW JERSEY

Prepared for:

U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, Pennsylvania

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey

Preparer: Eric P. Schrading
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

January 1995

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LIST OF APPENDICES

I. INTRODUCTION

The U.S. Fish and Wildlife Service (Service) has reviewed the U.S. Army Corps of Engineers, Philadelphia District (District) Draft Report of the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey: Benthic Animal Assessment of Potential Borrow Source (1994). This report on benthic resources was produced by Battelle Ocean Sciences. The Service also reviewed the Service's previous Planning Aid Report (PAR) for the Brigantine Inlet to Absecon Inlet, Brigantine Inlet to Great Egg Harbor Inlet Beach, New Jersey Shore Protection Reconnaissance Study (1991). The purpose of reviewing the PAR was to update information and provide additional information. Therefore, review comments of the benthic report and updated and additional information on the 1991 PAR are provided in this Planning Aid Report.

II. U.S. FISH AND WILDLIFE SERVICE REVIEW COMMENTS

A. BENTHIC ANIMAL ASSESSMENT OF POTENTIAL BORROW SOURCES

The information in the benthic report provides an adequate evaluation of the general water quality, substrate, and most benthic invertebrate communities at each of the two proposed borrow sites. Information in the report provides detailed data on benthic invertebrate communities with regard to abundance, species richness, diversity, and biomass. Specific review comments are presented below.

1. Surf Clam Density

Battelle Ocean Sciences used a 0.1 m^2 Young-modified Van Veen grab sampler to sample benthic invertebrates. This type of grab sampler does not accurately sample adult surf clams (*Spisula solidissima*), primarily because the grab sampler does not sample a sufficient depth in the hard substrate at the proposed borrow sites (Norman, pers. comm., 1995). Therefore, the benthic report does not accurately reflect surf clam density and thus the potential impact on surf clams. Surf clam populations in and adjacent to both proposed borrow sites are considered to be of medium to high density (Norman, pers. comm., 1995). In addition, the area north of Absecon Inlet is designated by the State as a surf clam conservation zone. The New Jersey Bureau of Shellfisheries suggests identifying potential borrow sites within the Absecon Inlet or within the channel to avoid impacts on surf clams (Norman, pers. comm., 1995). The Service recommends that the District examine alternatives that would avoid or minimize impacts on surf clams through coordination with the New Jersey Bureau of Shellfisheries.

2. Diversity Index

Diversity indices were identified in the benthic report including the Shannon Diversity Index, Pielou's evenness, and Simpson's Dominance Index. While these indices are helpful to determine the diversity of animal life at study sites, there is some confusion among ecologists regarding proper usage of diversity indices and their interpretation. Luckenbach et al. (1988) in discussion of benthic assessment procedures state:

> "Often diversity index values are reported without reference to external or internal standards (as though we all know exactly what $H' = 2.31$ means). The expectation certainly exists that highly disturbed habitats will have lower diversity than lesser disturbed habitats, but apart from this expectation no generally accepted standard exists for categorizing benthic assemblages as disturbed on the basis of diversity measures."

As such, diversity indices should be analyzed with some caution as indicators of habitat quality. The Service recommends relying primarily on the components of the diversity indices (i.e., species diversity, species richness, and the distribution of the number of individuals among the species) rather than on the diversity indices alone.

3. Alternative Borrow Sites

The District's Brigantine Inlet to Great Egg Harbor Inlet Reconnaissance Study identifies and discusses 10 potential borrow sites for the proposed shore protection study. However, the benthic report only analyzes two of these sites (Site 24 and 27). It is unclear why only two of the 10 potential borrow sites were analyzed by the District's contractor: Battelle Ocean Sciences. Obviously, benthic habitat information from all 10 potential borrow sites would facilitate the selection of the best borrow source alternative. Therefore, the Service recommends that the District identify why only 2 of the 10 potential borrow sites were assessed for benthic invertebrate habitat. Any future documents prepared pursuant to the National Environmental Policy Act must contain an explanation of why alternatives were eliminated from further consideration (40 CFR Part 1502.14(a)). In addition, if other borrow sites continue to be viable alternatives, the Service recommends that additional benthic habitat assessments be conducted in order to select the best borrow source alternative.

Borrow Area B had higher average abundance (170 individuals/0.1 m^2), species richness (12), and biomass (113 g/0.1 m^2) of the two sites. Diversity indices between the two sites were similar with Borrow Area B having slightly higher species diversity. Dominant taxa among both borrow sites were similar, consisting primarily of Annelids and Arthropods. Bray-Curtis Similarity Indices indicated dissimilar areas in the southwest corner of Borrow Area B and west of Sampling Station A8 in Borrow Area A, indicating high habitat quality. Judging between the two borrow sites studied and based on benthic habitat information at the sites, as assessed in the benthic report, the Service recommends that the District use borrow material from Borrow Area A. In addition, the Service recommends that the Corps remove borrow material from Borrow Area A to begin in the eastern portion of the site (where the habitat quality is the lowest) and move west, and limit removal of borrow material west of Station A8.

B. FEDERALLY-LISTED ENDANGERED AND THREATENED SPECIES

The federally-listed threatened piping plover (*Charadrius melodus*) nests throughout the proposed project area from Brigantine Inlet to Cape May Inlet. Piping plovers nest on sandy beaches above the high-tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand.

Food for adult plovers and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

Development along the coastal shoreline for residential and commercial uses, and the subsequent stabilization of the once shifting and dynamic beach ecosystem via seawalls, breakwaters, jetties, and groins have resulted in the destruction and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for the piping plover.

Beach nourishment or stabilization activities may create additional nesting areas for piping plovers on the various beaches within the project area. However, the likelihood of piping plovers successfully nesting on recreational beaches during the summer is low due to human disturbance. If piping plovers nest on beaches frequented by humans, recreational activities (e.g., sunbathing, kite-flying, fishing) could adversely impact nesting piping plovers.

Federally-listed species are afforded protection under the Endangered Species Act pursuant to Section 7(a)(2), which requires every federal agency, in consultation with the Service, to insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat.

While it is unlikely that piping plovers would nest on many of the beaches that are frequented by humans within the project area, nesting may become possible due to creation of suitable habitat as a result of the project. Therefore, in the event that piping plovers nest on the beaches frequented by humans within the project area during beach nourishment activities or after those activities are completed, the Service recommends that protective zones be established in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines) (Appendix A), dated April 15, 1994. The Service further recommends that such protective zones for piping plover nests take precedence over all recreational activities (e.g., vehicle access, sunbathing, kite-flying, swimming). In addition, other measures identified in the Guidelines may be necessary such as prohibiting dogs in the vicinity of protective zones or ensuring that all dogs are leashed. Establishment of protective zones would be coordinated by the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program.

Information in the Service's 1991 PAR identified other federally-listed endangered and threatened species found within the study area, including the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), Kemp's Ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*). Several federally-listed marine mammals that frequent the project area are also identified in the 1991 PAR. Except for nesting habitat for sea turtles, principal responsibility for marine turtles and marine mammals is under the jurisdiction of the National Marine Fisheries Service (NMFS). The Service continues to recommend that NMFS be contacted for further information regarding federally-listed sea turtles and marine mammals.

C. PLANNING AID REPORT (1991)

The Service's 1991 PAR presented information on fish and wildlife resources within the Brigantine Inlet to Great Egg Harbor Inlet project area. This information is also relevant to fish and wildlife resources within the Townsends Inlet to Cape May Inlet project area. The following provides an update of the information in the 1991 PAR and identifies additional information, not included in the 1991 PAR, which is relevant to the Townsends Inlet to Cape May Inlet portion of the District's New Jersey Shore Protection study area.

1. Priority Wetlands

The Emergency Wetlands Resources Act of 1986 (PL 99-645) directs the Department of the Interior to identify specific wetland sites that should receive priority attention for acquisition by federal and State agencies using Land and Water Conservation Fund monies. In the 1991 PAR, the Service (page 15) identified the entire back bay region behind Brigantine Island, which includes the project area, as having been designated by the Service as a Priority Wetland Site. In addition, most of the back bay region from Brigantine Inlet to Cape May Inlet, the beach immediately north of Herefords Inlet, and the beaches north and south of Brigantine Inlet are designated by the Service as Priority Wetlands.

2. Colonial Nesting Waterbirds

Information in the 1991 PAR (page 15) presented a discussion of colonial waterbirds, which commonly nest throughout the project area from Brigantine Inlet to Cape May Inlet. However, Appendix D in the report only identified colonial waterbird nesting colonies in the Reeds Bay / Absecon Bay area. Additional colonial waterbird nest sites are located throughout the project area from Townsends Inlet to Cape May Inlet. A 1984-85 survey (Andrews, 1990) of the northeast coast of the United States by the Service found 16 species of colonial waterbirds nesting in 37 separate colonies in the beach and bay areas between Townsends Inlet and Cape May Inlet (Appendix B). Most of the species reported by Andrews (1990) as within the study area are the same as those identified in the Reeds Bay / Absecon Bay area except for the great blue heron (*Ardea herodias*) and the black skimmer (*Rynchops niger*), which occur in the study area.

3. State-listed Endangered and Threatened Species

Most of the State-listed endangered and threatened species that occur between Brigantine Inlet and Cape May Inlet are identified in the 1991 PAR; however, there are a few species that occur within the project area that were not discussed in the 1991 PAR (New Jersey Division of Fish, Game and Wildlife, 1994). Nesting populations of the State-listed endangered least tern (*Sterna antillarum*) and black skimmer occur in beach habitat within the project area. The State-listed endangered short-eared owl (*Asio flammeus*), and the State-listed threatened great blue heron and little blue heron (*Florida caerulea*) also use wetland habitats within the study area; however, current breeding status of the short-eared owl in the project area is unknown (New Jersey Division of Fish, Game and Wildlife, 1994). The pied-billed grebe (*Podilymbus podiceps*), a State-listed endangered species, uses lakes, ponds, sluggish streams, and marshes; however, during migration and in the winter the grebe does use brackish bays and estuaries within the project area. The black rail (*Laterallus jamaicensis*) also inhabits the salt and brackish marshes of the project area (New Jersey Division of Fish, Game and Wildlife, 1994).

The Service continues to recommend that the New Jersey Natural Heritage Program and the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program be contacted for information regarding State-listed endangered and threatened species as identified in the 1991 PAR (page 19).

III. U.S. FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The Service recommends that the following measures be incorporated into the District's planning process to minimize potential adverse impacts on fish and wildlife resources:

1. Examine alternatives that would avoid or minimize impacts on surf clams through coordination with the New Jersey Bureau of Shellfisheries.

2. Base site selection on habitat quality reflected in the individual components (i.e., species richness, species diversity, and distribution of individuals) of the diversity index, rather than on the diversity index alone.

3. Identify why only 2 of the 10 potential borrow sites were assessed for benthic invertebrate habitat. If other borrow sites continue to be viable alternatives, additional benthic invertebrate habitat assessments are recommended in order to select the best borrow source alternative.

4. If the only alternative borrow sites are Borrows Areas A and B discussed in the benthic report, use borrow material from Borrow Area A. In addition, remove borrow material from Borrow Area A beginning in the eastern portion of the site moving toward the west and limit removal of borrow material west of Station A8 (area of highest benthic habitat quality).

5. In the event that piping plovers nest on beaches used by humans within the project area, establish protective zones in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines), dated April 15, 1994. Protective zones for piping plover nests shall take precedence over all recreational activities (e.g., vehicle access, sunbathing, kite-flying, swimming, walking). In addition, other measures identified in the Guidelines shall be instituted, such as prohibiting dogs in the vicinity of protective zones or ensuring that all dogs are leashed. Establishment of the protective zones would be coordinated by the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program.

6. Contact the National Marine Fisheries Service for further information regarding federally-listed sea turtles and marine mammals.

7. Contact the New Jersey Natural Heritage Program and the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program for information regarding State-listed endangered and threatened species.

IV. REFERENCES

A. LITERATURE CITED

Andrews, R. 1990. Coastal Waterbird Colonies: Maine to Virginia. 1984-85. An Update of an Atlas Based on 1972 Data Showing Colony Locations, Species, and Nesting Pairs at Both Time Periods. USDI, Fish and Wildlife Service, Region 5, Newton Corner, Massachusetts. 807 pp.

Luckenbach, M.W., R.J. Diaz, and L.C. Schaffner. 1988. Benthic Assessment Procedures, Appendix I, Project 8. Virginia Institute of Marine Science, Gloucester Point, Virginia.

New Jersey Division of Fish, Game and Wildlife. 1994. Notable Information of New Jersey Animals Database. New Jersey Department of Environmental Protection. Trenton, New Jersey.

B. PERSONAL COMMUNICATIONS

Norman, J. 1995. Fisheries Biologist. Bureau of Shellfisheries. New Jersey Division of Fish, Game and Wildlife. Trenton, New Jersey.

APPENDIX A

Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act

United States Department of the Interior

TAKE PRIDE IN AMERICA

FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
Hadley, MA 01035-9589

In Reply Refer To:
FWS/Region 5/ES-TE

APR 21 1994

Mr. John H. Spencer
Bureau of Natural Resources
Department of Environmental Protection
79 Elm Street
Hartford, Connecticut 06106-5127

Dear Mr. Spencer:

Enclosed are the U.S. Fish and Wildlife Service's Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act. This is the final version of the draft guidelines sent to you for review and comment on March 18, 1994.

These guidelines, based on the best available biological information, provide a flexible approach to protecting piping plovers, while minimizing impacts on beach recreation on non-Federal lands. Management techniques recommended in these guidelines will generally facilitate pedestrian access to the shoreline throughout the plover's breeding cycle. Recommended management options that include intensive monitoring will, in most cases, also allow use of motorized vehicles except when flightless chicks are present.

Please contact Anne Hecht at 508-443-4325 or Paul Nickerson at 413-253-8615 if you have questions about these guidelines or other aspects of the piping plover recovery effort.

Sincerely,

Ronald E. Lambertson

Regional Director

Enclosure

GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT

Northeast Region, U.S. Fish and Wildlife Service
April 15, 1994

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service (Service), with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the Service's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have endangered species protection obligations under Section 7 of the Endangered Species Act (see section I below) or under Executive Orders 11644 and 11989[1] that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

This document contains four sections: (I) a brief synopsis of the legal requirements that afford protection to nesting piping plovers; (II) a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle; (III) guidelines for protecting piping plovers from recreational activities on Atlantic Coast beaches; and (IV) literature cited.

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[1] Executive Order 11644, Use of Off-Road Vehicles on the Public Lands and Executive Order 11989, Off-Road Vehicles on Public Lands pertain to lands under custody of the Secretaries of Agriculture, Defense, and Interior (except for Indian lands) and certain lands under the custody of the Tennessee Valley Authority.

I. LEGAL CONSIDERATIONS

Section 9 of the Endangered Species Act (ESA) prohibits any person subject to the jurisdiction of the United States from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. A "person" is defined in Section 3 to mean "an individual, corporation, partnership, trust, association, or any other private entity; or any officer, employee, agent, department, or instrumentality of the Federal Government, of any State, municipality, or political subdivision of a State, or of any foreign government; any State, municipality, or political subdivision of a State; or any other entity subject to the jurisdiction of the United States." Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Penalties for violations of Section 9 are provided in Section 11 of the ESA; for threatened species, these penalties include fines of up to $25,000, imprisonment for not more than six months, or both.

Section 10 of the ESA and related regulations provide for permits that may be granted to authorize acts prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. States that have Cooperative Agreements under Section 6 of the ESA, may provide written authorization for take that occurs in the course of implementing conservation programs. For example, State agencies have authorized certain biologists to construct predator exclosures for piping plovers. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit, if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the Service determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized.

Section 7 of the ESA may be pertinent to beach managers and landowners in situations that have a Federal nexus. Section 7 requires Federal agencies to consult with the Service (or National Marine Fisheries Service for marine species) prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7 consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

Piping plovers, as well as other migratory birds such as least terns, common terns, American oystercatchers, laughing gulls, herring gulls, and great black-backed gulls, their nests, and eggs are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. Violators may be fined up to $5000 and/or imprisoned for up to six months.

Almost all States within the breeding range of the Atlantic Coast piping plover population list the species as State threatened or endangered (Northeast Nongame Technical Committee 1993). Various laws and regulations may protect State-listed species from take, but the Service has not ascertained the adequacy of the guidelines presented in this document to meet the requirements of any State law.

II. LIFE HISTORY AND THREATS FROM HUMAN DISTURBANCE

Piping plovers are small, sand-colored shorebirds that nest on sandy, coastal beaches from South Carolina to Newfoundland. Since 1986, the Atlantic Coast population has been protected as a threatened species under provisions of the U.S. Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1985). The U.S. portion of the population was estimated at 875 pairs in 1993 (U.S. Fish and Wildlife Service 1993). Many characteristics of piping plovers contribute to their susceptibility to take due to human beach activities.

LIFE HISTORY

Piping plovers begin returning to their Atlantic Coast nesting beaches in mid-March (Coutu et al. 1990, Cross 1990, Goldin 1990, MacIvor 1990, Hake 1993). Males establish and defend territories and court females (Cairns 1982). Eggs may be present on the beach from mid-April through late July. Clutch size is generally four eggs, and the incubation period[2] usually lasts for 27-28 days. Piping plovers fledge only a single brood per season, but may renest several times if previous nests are lost. Chicks are precocial[3] (Wilcox 1959, Cairns 1982). They may move hundreds of yards from the nest site during their first week of life (see Table 1, Summary of Chick Mobility Data). Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard et al. 1993).

Piping plover nests are situated above the high tide line on coastal beaches, sand flats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes. They may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells or cobble (Bent 1929, Burger 1987a, Cairns 1982, Patterson 1988, Flemming et al. 1990, MacIvor 1990,

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[2] "Incubation" refers to adult birds sitting on eggs, to maintain them at a favorable temperature for embryo development.

[3] "Precocial" birds are mobile and capable of foraging for themselves within several hours of hatching.

Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (Ammophila breviligulata) or other vegetation (Patterson 1988, Flemming et al. 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans or mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines[4], and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu et al. 1990, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu et al. 1990, McConnaughey et al. 1990, Loegering 1992, Goldin 1993, Hoopes 1993) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin et al. 1990). Feeding activities of chicks may be particularly important to their survival. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon (see Table 1). Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1993) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

THREATS FROM NONMOTORIZED BEACH ACTIVITIES

Sandy beaches that provide nesting habitat for piping plovers are also attractive recreational habitats for people and their pets. Nonmotorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush

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[4] Wrack is organic material including seaweed, seashells, driftwood and other materials deposited on beaches by tidal action.

eggs (Burger 1987b, Hill 1988, Shaffer and Laporte 1992, Cape Cod National Seashore 1993, Collazo et al. 1994). Unleashed dogs may chase plovers (McConnaughey et al. 1990), destroy nests (Hoopes et al. 1992), and kill chicks (Cairns and McLaren 1980).

Pedestrians may flush incubating plovers from nests (see Table 2, Summary of Data on Distances at Which Plovers React to Disturbance), exposing eggs to avian predators or causing excessive cooling or heating of eggs. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991). Excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Fireworks are highly disturbing to piping plovers (Howard et al. 1993). Plovers are particularly intolerant of kites, compared with pedestrians, dogs, and vehicles; biologists believe this may be because plovers perceive kites as potential avian predators (Hoopes et al. 1992).

THREATS FROM MOTOR VEHICLES

Unrestricted use of motorized vehicles on beaches is a serious threat to piping plovers and their habitats. Vehicles can crush eggs (Wilcox 1959; Tull 1984; Burger 1987b; Patterson et al. 1991; United States of America v. Breezy Point Cooperative, Inc., U.S. District Court, Eastern District of New York, Civil Action No. CV-90-2542, 1991; Shaffer and Laporte 1992), adults, and chicks. In Massachusetts and New York, biologists documented 14 incidents in which 18 chicks and 2 adults were killed by vehicles between 1989 and 1993 (Melvin et al. 1994). Goldin (1993) compiled records of 34 chick mortalities (30 on the Atlantic Coast and 4 on the Northern Great Plains) due to vehicles. Many biologists that monitor and manage piping plovers believe that many more chicks are killed by vehicles than are found and reported (Melvin et al. 1994). Beaches used by vehicles during nesting and brood-rearing periods generally have fewer breeding plovers than available nesting and feeding habitat can support. In contrast, plover abundance and productivity has increased on beaches where vehicle restrictions during chick-rearing periods have been combined with protection of nests from predators (Goldin 1993; S. Melvin, pers. comm., 1993).

Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitats in the wrack line and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings et al. 1990, Strauss 1990, Howard et al. 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes et al. 1992, Goldin 1993). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin et al. 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed (see Table 1).

Vehicles may also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate, by creating ruts that may trap or impede movements of chicks, and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes et al. 1992, Goldin 1993).

III. GUIDELINES FOR PROTECTING PIPING PLOVERS FROM RECREATIONAL DISTURBANCE

The Service recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NONMOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least 50 meter-radius around nests above the high tide line should be delineated with warning signs and symbolic fencing[5]. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of

[5] "Symbolic fencing" refers to one or two strands of light-weight string, tied between posts to delineate areas where pedestrians and vehicles should not enter.

incubating adults, and to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach.

Available data indicate that a 50 meter buffer distance around nests will be adequate to prevent harassment of the majority of incubating piping plovers. However, fencing around nests should be expanded in cases where the standard 50 meter-radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance. Data from various sites distributed across the plover's Atlantic Coast range indicates that larger buffers may be needed in some locations (see Table 2). This may include situations where plovers are especially intolerant of human presence, or where a 50 meter-radius area provides insufficient escape cover or alternative foraging opportunities for plover chicks.[6]

In cases where the nest is located less than 50 meters above the high tide line, fencing should be situated at the high tide line, and a qualified biologist should monitor responses of the birds to passersby, documenting his/her observations in clearly recorded field notes. Providing that birds are not exhibiting signs of disturbance, this smaller buffer may be maintained in such cases.

On portions of beaches that receive heavy human use, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. If nests are discovered outside fenced areas, fencing should be extended to create a sufficient buffer to prevent disturbance to incubating adults, eggs, or unfledged chicks.

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[6] For example, on the basis of data from an intensive three year study that showed that plovers on Assateague Island in Maryland flush from nests at greater distances than those elsewhere (Loegering 1992), the Assateague Island National Seashore established 200 meter buffers zones around most nest sites and primary foraging areas (Assateague Island National Seashore 1993). Following a precipitous drop in numbers of nesting plover pairs in Delaware in the late 1980's, that State adopted a Piping Plover Management Plan that provided 100 yard buffers around nests on State park lands and included intertidal areas (Delaware Department of Natural Resources and Environmental Control 1990).

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31.

Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged.

MOTOR VEHICLE MANAGEMENT

The Service recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the Service or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

If data from several years of plover monitoring suggests that significantly more habitat is available than the local plover population can occupy, some suitable habitat may be left unposted if the following conditions are met:

1. The Service <u>OR</u> a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Estimates the number of pairs likely to nest on the site based on the past monitoring and regional population trends.

<u>AND</u>

B. Delineates the habitat that will be posted or fenced prior to April 1 to assure a high probability that territorial plovers will select protected areas in which to court and nest. Sites where nesting or courting plovers were observed during the last three seasons as well as other habitat deemed most likely to be pioneered by plovers should be included in the posted and/or fenced area.

<u>AND</u>

C. Provides for monitoring of piping plovers on the beach by a qualified biologist(s). Generally, the frequency of monitoring should be not less than twice per week prior to May 1 and not less than three times per week thereafter. Monitoring should occur daily whenever moderate to large numbers of vehicles are on the beach. Monitors should document locations of territorial or courting plovers, nest locations, and observations of any reactions of incubating birds to pedestrian or vehicular disturbance.

<u>AND</u>

2. All unposted sites are posted immediately upon detection of territorial plovers.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2000 meter-wide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each side of the brood. In some cases, highly mobile broods may require protected areas up to 1000 meters, even where they are intensively monitored. Protected areas should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles. In a few cases, where several years of data documents that piping plovers on a particular site feed in only certain habitat types, the Service or the State wildlife management agency may provide written concurrence that vehicles pose no danger to plovers in other specified habitats on that site.

Timing of Vehicle Restrictions in Chick Habitat

Restrictions on use of vehicles in areas where unfledged plover chicks are present should begin on or before the date that hatching begins and continue until chicks have fledged. For purposes of vehicle management, plover chicks are considered fledged at 35 days of age or when observed in sustained flight for at least 15 meters, whichever occurs first.

When piping plover nests are found before the last egg is laid, restrictions on vehicles should begin on the 26th day after the last egg is laid. This assumes an average incubation period of 27 days, and provides a 1 day margin of error.

When plover nests are found after the last egg has been laid, making it impossible to predict hatch date, restrictions on vehicles should begin on a date determined by one of the following scenarios:

1) With intensive monitoring: If the nest is monitored at least twice per day, at dawn and dusk (before 0600 hrs and after 1900 hrs) by a qualified biologist, vehicle use may continue until hatching begins. Nests should be monitored at dawn and dusk to minimize the time that hatching may go undetected if it occurs after dark. Whenever possible, nests should be monitored from a distance with spotting scope or binoculars to minimize disturbance to incubating plovers.

OR

2) Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions on vehicles should begin at least 5 days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the Service recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property; or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, eg. by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

1. Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.

2. Speed of vehicles should not exceed five miles per hour.

3. Use of open 4-wheel motorized all-terrain vehicles (ATVs) or non-motorized all-terrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded operators.

4. A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.

Essential vehicles should avoid driving on the wrack line, and travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

SITE-SPECIFIC MANAGEMENT GUIDANCE

The guidelines provided in this document are based on an extensive review of the scientific literature and are intended to cover the vast majority of situations likely to be encountered on piping plover nesting sites along the U.S. Atlantic Coast. However, the Service recognizes that site-specific conditions may lead to anomalous situations in which departures from this guidance may be safely implemented. The Service recommends that landowners who believe such situations exist on their lands contact either the Service or the State wildlife agency and, if appropriate, arrange for an on-site review. Written documentation of agreements regarding departures from this guidance is recommended.

In some unusual circumstances, Service or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the Service or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

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Table 2. Summary of Data on Distances at which Piping Plovers React to Disturbance

Source	Location	Data
Flushing of Incubating Birds by Pedestrians		
Flemming et al. 1988 (p.326)	Nova Scotia	Adults usually flushed from the nests at distances <40 m; however, great variation existed and reaction distances as great as 210 m were observed.
Cross 1990 (p.47)	Virginia	Mean flushing distances in each of two years were 47 m (n=181, range = 5 m to 300 m) and 25 m (n=214, range = 2 m to 100 m).
Loegering 1992 (p.61)	Maryland	Flushing distances averaged 78 m (n=43); range was 20 m to 174 m. Recommended use of 225 m disturbance buffers on his site.
Cross and Terwilliger 1993	Virginia	Mean flushing distance for all years on all sites (Virginia plover sites, 1986-91) was 63 m (n=201, SD=31, range = 7 m to 200 m). Differences among years were not significant, but differences among sites were.
Hoopes 1993 (p.72)	Massachusetts	Mean flushing distance for incubating plovers was 24 m (n=31).
Disturbance to Non-Incubating Birds		
Hoopes 1993 (p.89)	Massachusetts	Mean response distance (all ages, all behaviors) was 23 m for pedestrian disturbances (range = 10 m to 60 m), 40 m for vehicles (range = 30 m to 70 m), 46 m for dogs/pets (range = 20 m to 100 m), and 85 m for kites (range = 60 m to 120 m).
Goldin 1993 (p.74)	New York	Average flushing distance for adult and juvenile plovers was 18.7 m for pedestrian disturbances (n=585), 19.5 m for joggers (n=183), and 20.4 m for vehicles (n=111). Pedestrians caused chicks to flush at an average distance of 20.7 m (n=175), joggers at 32.3 m (n=37), and vehicles at 19.3 m (n=7). Tolerance of individual birds varied; one chick moved 260 m in direct response to 20 disturbances in 1 hour.

Table 1. Summary of Chick Mobility Data

Source	Location	Data
Patterson 1988 (p.40)	Maryland and Virginia	18 of 38 broods moved to feeding areas more than 100 meters from their nests; 5 broods moved more than 600 meters (distance measured parallel to wrackline).
Cross 1989 (p.23)	Virginia	At three sites, observers relocated broods at mean distances from their nests of 153 m +/-97m (44 observations, 14 broods), 32 m +/-7 m (8 observations, 3 broods), and 492 m +/-281 m (12 observations, 4 broods).
Coutu et al. 1990 (p.12)	North Carolina	Observations of 11 broods averaged 212 m from their nests; 3 broods moved 400-725 m from nest sites.
Strauss 1990 (p.33)	Massachusetts	10 chicks moved more than 200 m during first 5 days post-hatch while 19 chicks moved less than 200 meters during same interval.
Loegering 1992 (p.72)	Maryland	Distances broods moved from nests during first 5 days post-hatch averaged 195 m in Bay habitat (n=10), 141 m in Interior habitat (n=36), and 131 m in Ocean habitat (n=41). By 21 days, average movement in each habitat had, respectively, increased to 850 m (n=1), 464 m (n=10), and 187 m (n=69). One brood moved more than 1000 m from its nest.
Melvin et al. 1994	Massachusetts and New York	In 14 incidents in which 18 chicks were killed by vehicles, chicks were run over $\leq$ 10 m to $\leq$ 900 m from their nests. In 7 of these instances, mortality occurred $\geq$ 200 m from the nest.

APPENDIX B

Coastal Waterbird Colonies Within the Project Area
(Source: Andrews, 1990)

Table 1. Codes used to designate species of colonial waterbirds and methods used to estimate nesting populations.

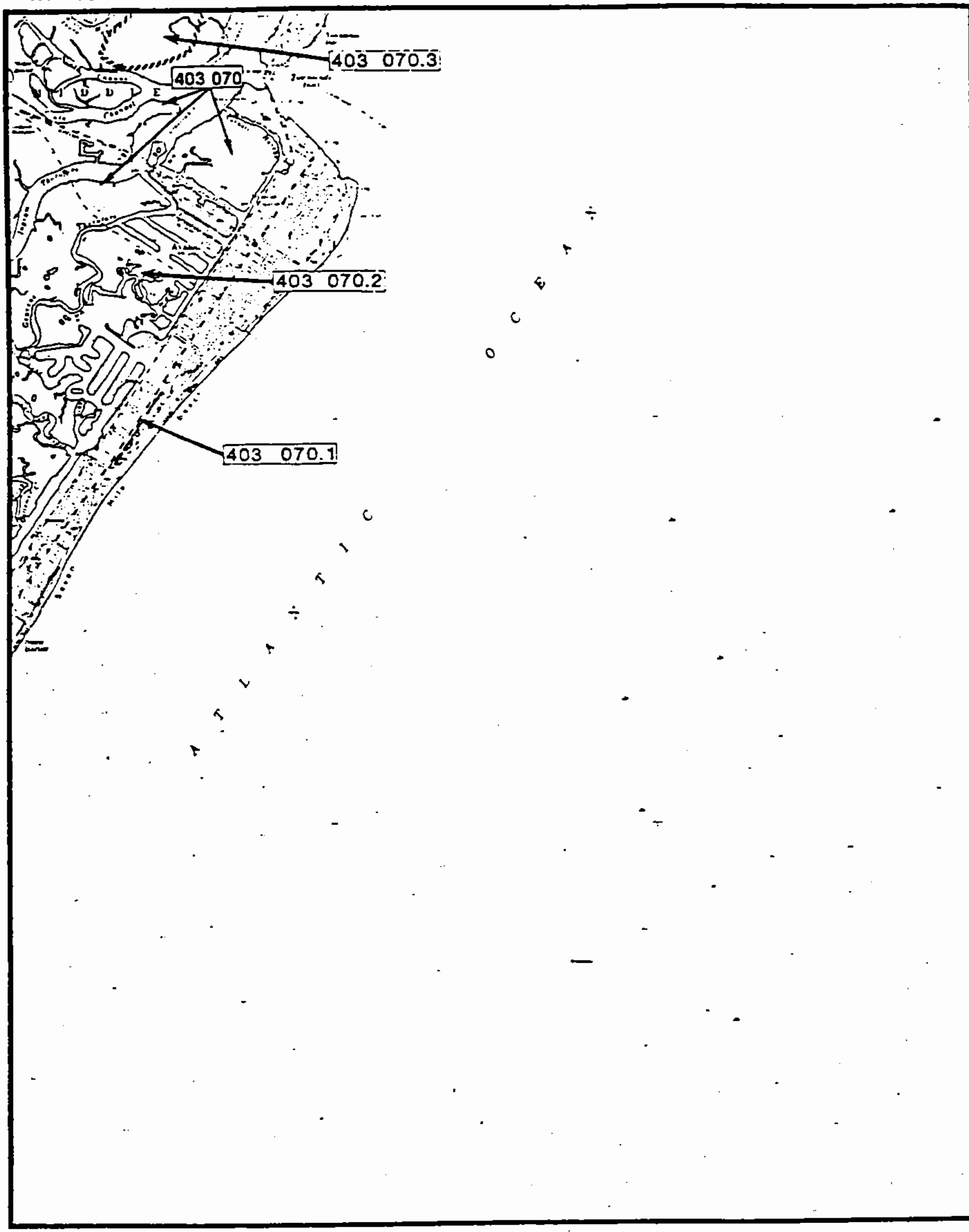
Species Codes

LSPE - Leach's Storm-Petrel
GRCO - Great Cormorant
DCCO - Double-crested Cormorant
GBHE - Great Blue Heron
GREG - Great Egret
SNEG - Snowy Egret
LBHE - Little Blue Heron
TCHE - Tricolored Heron
CAEG - Cattle Egret
BCNH - Black-crowned Night-Heron
YCNH - Yellow-crowned Night-Heron
WHIB - White Ibis
GLIB - Glossy Ibis
COEI - Common Eider
LAGU - Laughing Gull
CBHG - Common Black-headed Gull
HEGU - Herring Gull
GBBG - Great Black-backed Gull
GBTE - Gull-billed Tern
CATE - Caspian Tern
RYTE - Royal Tern
SATE - Sandwich Tern
RSTE - Roseate Tern
COTE - Common Tern
ARTE - Arctic Tern
FOTE - Forster's Tern
LETE - Least Tern
BLSK - Black Skimmer
RAZO - Razorbill
BLGU - Black Guillemot
ATPU - Atlantic Puffin

Inventory Method Codes

AE - Adult estimate
AEa - Adult estimate-air
AEg - Adult estimate-ground
AEb - Adult estimate-boat
AC - Total adult count
NE - Nest estimate
NEg - Nest estimate-ground
NC - Total nest count
NCa - Nest count-air
PC - Photo count
U - Unknown

M 403 070 AVALON



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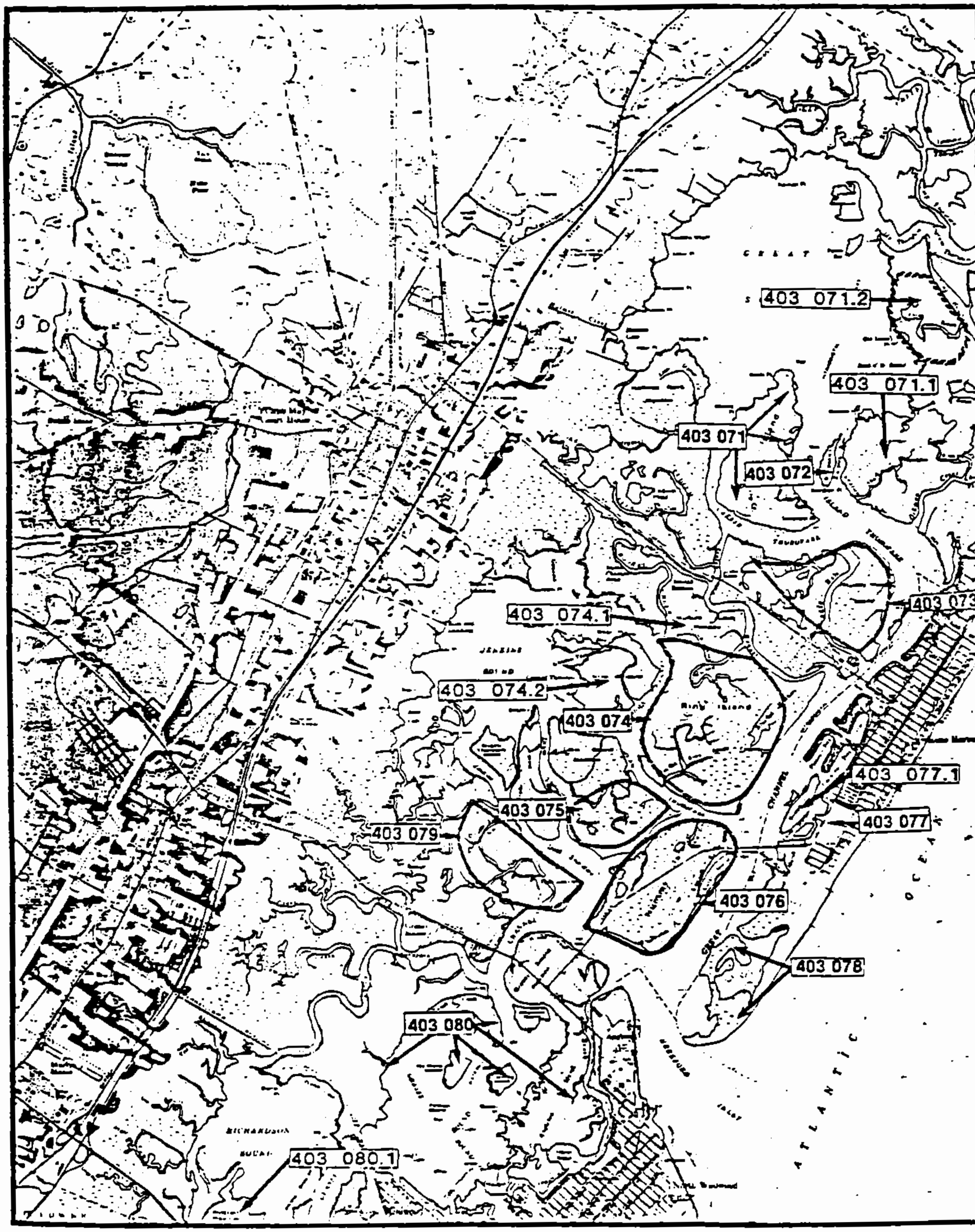
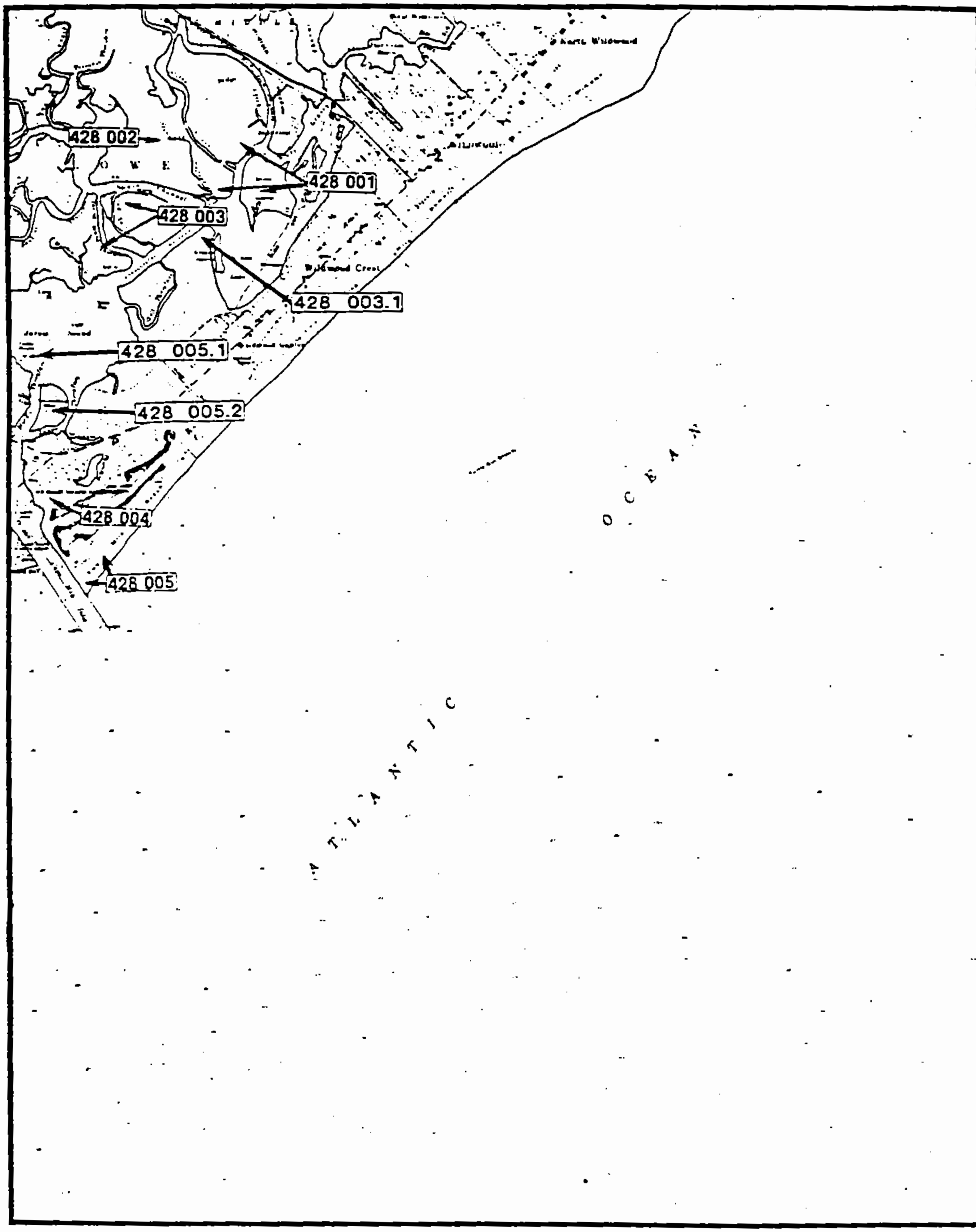
N 403 071 TO 080 STONE HARBOR



595

A 428 001 TO 005 WILDWOOD



403 069 TOWNSENDS INLET MARSHES, NJ

LOCATION: 39 08 ,74 43
ISLAND SIZE: 145
COLONY SIZE: 4
HABITAT: Island-marsh
NEST SUBSTRATE: Shrubs, grass
OWNERSHIP: Private-World Wildlife Fund

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG	5/25	2	AEa	June	5	AEa
SNEG	6/2	225	AEa	June	155	AEa
LBHE	6/2	15	AEa	June	29	AEa
TCHE	6/2	16	AEa	June	45	AEa
BCNH	5/9	20	AEa	June	135	AEa
YCNH	5/9	?	AEa			
GLIB	6/2	40	AEa	June	8	AEa
HEGU	6/2	50	AEa	June	182	AEa

403 070 AVALON & INGRAM THOROFARE, NJ

LOCATION: 39 07 ,74 43
ISLAND SIZE: -
COLONY SIZE: 18
HABITAT: Islands-dredge/fill
NEST SUBSTRATE: Trees, wrack, sand
OWNERSHIP: Public-State of NJ

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG	6/8	9	AEa	June	16	AEa
SNEG	6/8	60	AEa			
TCHE				June	1	AE
BCNH	6/8	50	AEa	June	25	AEa
YCNH	6/8	4	AEa			
GLIB	6/8	25	AEa			
COTE	6/13	130	AEg	June	80	AE
BLSK	June	250	AEg	June	4	AE

403 070.1 AVALON DUNES NJ

LOCATION: 39 05 ,74 44
ISLAND SIZE: -
COLONY SIZE: <2
HABITAT: Mainland-dunes
NEST SUBSTRATE: Trees
OWNERSHIP: ?

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
YCNH				June	20	AEa

No report for 1977.

403 070.2 CRAVENS THOROFARE, NJ

LOCATION: 39 06 ,74 44
ISLAND SIZE: -
COLONY SIZE: <2
HABITAT: Mainland-marsh,dredge/fill
NEST SUBSTRATE: Sand,grass,shrubs,trees
OWNERSHIP: ?

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG				June	2	AEa
BCNH				June	35	AEa
HEGU				June	6	AEa
BLSK				June	65	AEa

No report for 1977.

403 070.3 MIDDLE THOROFARE, NJ

LOCATION: 39 07 ,74 44
ISLAND SIZE: -
COLONY SIZE: 20
HABITAT: Mainland-marsh
NEST SUBSTRATE: Grass,wrack
OWNERSHIP: ?

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU				June	30	AEa
FOTE				June	100	AEa

No report for 1977.

403 071 GULL ISLAND, NJ

LOCATION: 39 05 ,74 46
ISLAND SIZE: 108
COLONY SIZE: 30
HABITAT: Island-dredge/fill,marsh
NEST SUBSTRATE: Shrubs,grass,wrack
OWNERSHIP: Public-State of NJ

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG	5/9	?	AEa	June	2	AEa
SNEG	6/1	110	AEa	June	70	AEa
LBHE	6/1	6	AEa	June	15	AEa
CAEG	6/1	20	AEa			
TCHE	6/1	2	AEa	June	1	AEa
BCNH	6/1	2	AEa	June	3	AEa
YCNH	6/1	1	AEa			
GLIB	6/1	70	AEa			
LAGU				June	1250	AEa
FOTE				June	100	AEa

403 071.1 OLDMAN CREEK, NJ

LOCATION: 39 04 ,74 45
ISLAND SIZE: 120
COLONY SIZE: 10
HABITAT: Island-marsh
NEST SUBSTRATE: Grass,wrack
OWNERSHIP: NJ

SPECIES	1977 DATE	1977 NESTING PAIRS	1977 INVENTORY METHOD	1985 DATE	1985 NESTING PAIRS	1985 INVENTORY METHOD
LAGU				June	1075	AEa
HEGU				June	10	AEa

No report for 1977.

403 071.2 LONG REACH, NJ

LOCATION: 39 06 ,74 45
ISLAND SIZE: 100
COLONY SIZE: 5
HABITAT: Island-marsh
NEST SUBSTRATE: Grass,wrack
OWNERSHIP: Unknown

SPECIES	1977 DATE	1977 NESTING PAIRS	1977 INVENTORY METHOD	1985 DATE	1985 NESTING PAIRS	1985 INVENTORY METHOD
LAGU				June	90	AEa
FOTE				June	260	AEa

No report for 1977.

403 072 STURGEON ISLAND, NJ

LOCATION: 39 05 ,74 46
ISLAND SIZE: 3
COLONY SIZE: 3
HABITAT: Island-marsh
NEST SUBSTRATE: Shrubs,grass-salt marsh
OWNERSHIP: Private-individual(s)

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
SNEG				June	150	AEa
TCHE				June	20	AEa
GLIB				June	35	AEa
LAGU	6/1	12	AEa			
HEGU	6/1	55	AEa	June	95	AEa
GBBG				June	14	AEa

403 073 MUDDY HOLE ISLAND, NJ

LOCATION: 30 04 ,74 46
ISLAND SIZE: 62
COLONY SIZE: 14
HABITAT: Island-dredge/fill,marsh
NEST SUBSTRATE: Grass-upland
OWNERSHIP: Public-State of NJ/Private-NJ Audubon individu

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU	6/1	5600	AEa	June	8900	AEa
HEGU	6/1	4	AEa			

403 074 RING ISLAND, NJ

LOCATION: 39 03 ,74 47
ISLAND SIZE: 227
COLONY SIZE: 227
HABITAT: Island-marsh
NEST SUBSTRATE: Grass
OWNERSHIP: Private-World Wildlife Fund

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU	6/1	9000	AEa	June	11900	AEa
HEGU				June	30	AEa
FOTE				June	80	AEa

403 074.1 MULFORD CREEK MEADOW, NJ

LOCATION: 39 04 ,74 47
ISLAND SIZE: 30
COLONY SIZE: 5
HABITAT: Island-dredge/fill on marsh
NEST SUBSTRATE: Shrubs,grass
OWNERSHIP: ?

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GBHE				June	104	AEa
COTE				June	36	AEa

No report for 1977.

403 074.2 WHITE ISLAND, NJ

LOCATION: 39 02 ,74 07
ISLAND SIZE: 100
COLONY SIZE: 10
HABITAT: Island-marsh
NEST SUBSTRATE: Grass
OWNERSHIP: Private

	----- 1977 -----			----- 1985 -----		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU				June	2300	AEa

No report for 1977.

403 075 GREAT FLAT, NJ

LOCATION: 39 03 ,74 48
ISLAND SIZE: 64
COLONY SIZE: <2
HABITAT: Island-dredge/fill
NEST SUBSTRATE: Shrubs,grass-salt marsh
OWNERSHIP: Unknown

	----- 1977 -----			----- 1985 -----		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU	6/1	2100	AEa	June	5300	AEa
HEGU	6/1	105	AEa	June	55	AEa
GBBG	6/1	10	AEa	June	7	AEa

403 076 NUMMY ISLAND, NJ

LOCATION: 39 02 ,74 48
ISLAND SIZE: 155
COLONY SIZE: 8
HABITAT: Island-marsh,dredge/fill
NEST SUBSTRATE: Grass-upland,shrubs,wrack
OWNERSHIP: Private-World Wildlife Fund

SPECIES	1977 DATE	1977 NESTING PAIRS	1977 INVENTORY METHOD	1985 DATE	1985 NESTING PAIRS	1985 INVENTORY METHOD
LAGU	6/1	950	AEa	June	2050	AEa
HEGU	6/1	290	AEa	June	95	AEa
GBBG	6/1	19	AEa	June	4	AEa
COTE	6/1	35	AEa	June	30	AEa
FOTE				June	18	AEa

403 077 STONE HARBOR, NJ

LOCATION: 39 02 ,74 46
ISLAND SIZE: -
COLONY SIZE: 10
HABITAT: Island-barrier
NEST SUBSTRATE: Trees,shrubs
OWNERSHIP: Public-Town of Stone Harbor (bird sanctuary)

SPECIES	1977 DATE	1977 NESTING PAIRS	1977 INVENTORY METHOD	1985 DATE	1985 NESTING PAIRS	1985 INVENTORY METHOD
GREG	6/8	280	AEg	June	225	AEa
SNEG	6/8	600	AEg	June	400	AEa
LBHE	6/8	80	AEg	June	2	AEa
CAEG	6/1	200	AEa	June	200	AEa
TCHE	6/8	60	AEg	June	2	AEa
BCNH	6/8	375	AEg	June	110	AEa
YCNH	6/1	40	AEa	June	10	AEa
GLIB	6/8	840	AEg	"	250	"

403 077.1 SEDGE ISLAND, STONE HARBOR, NJ

LOCATION: 39 02 ,74 36
ISLAND SIZE: 5
COLONY SIZE: 5
HABITAT: Island-marsh, dredge/fill
NEST SUBSTRATE: Grass, sand
OWNERSHIP: ?

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
HEGU				June	135	AEa
GBBG				June	14	AEa

No report for 1977.

403 078 STONE HARBOR POINT-7 MILE BEACH NJ

LOCATION: 39 03 ,74 45
ISLAND SIZE: -
COLONY SIZE: 8
HABITAT: Island-barrier
NEST SUBSTRATE: Sand, cobble
OWNERSHIP: Public-Borough of Stone Harbor

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LETE	6/23	100	AC			
BLSK				June	200	AEa

403 079 DEAD THOROFARE, NJ

LOCATION: 39 02 ,74 48
ISLAND SIZE: -
COLONY SIZE: 9
HABITAT: Islands-marsh
NEST SUBSTRATE: Wrack,grass
OWNERSHIP: Private-individual(s)

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU				June	310	AEa
COTE	6/1	55	AEa	June	60	AEa
FOTE	6/1	35	AEa	June	50	AEa

403 080 GRASSY SOUND MARSHES, NJ

LOCATION: 39 01 ,74 49
ISLAND SIZE: ?
COLONY SIZE: ?
HABITAT: Islands,mainland-some dredge/spoil
NEST SUBSTRATE: Grass,wrack,shrubs
OWNERSHIP: Private-individual(s)

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
SNEG				June	90	AEa
LBHE				June	1	AEa
TCHE				June	2	AEa
BCNH				June	30	AEa
YCNH				June	11	AEa
GLIB				June	1	AEa
LAGU	6/1	8	AEa	June	715	AEa
HEGU				June	67	AEa
GBBG				June	5	AEa
COTE	6/1	110	AEa	June	165	AEa
FOTE				June	205	AEa
BLSK	6/1	12	AEa			

609

403 080.1 HILDRETH MEADOWS, RICHARDSON SOUND, NJ

LOCATION: 39 00 ,74 51
ISLAND SIZE: -
COLONY SIZE: -
HABITAT: Island-marsh
NEST SUBSTRATE: Grass, wrack
OWNERSHIP: Private

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU				June	85	AEa

No report for 1977.

428 001 STINGAREE/SHAW CUTOFF, NJ

LOCATION: 38 59 ,74 51
ISLAND SIZE: 30
COLONY SIZE: 2
HABITAT: Island-marsh
NEST SUBSTRATE: Shrubs,trees
OWNERSHIP: Private-individual(s)

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG	6/10	22	AEg			
SNEG	6/10	200	AEg			
LBHE	6/1	12	AEa			
CAEG	6/10	200	AEg			
TCHE	6/10	8	AEg			
BCNH	6/1	30	AEa	June	80	AEa
YCNH	6/1	14	AEa	June	19	AEa
GLIB	6/10	900	AEg	June	12	AEa

428 002 STITES CREEK, NJ

LOCATION: 38 59 ,74 51
ISLAND SIZE: -
COLONY SIZE: 70
HABITAT: Mainland-marsh
NEST SUBSTRATE: Grass-salt marsh
OWNERSHIP: Private-Corporation

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU	6/1	70	AEa			

Site not used on 1983 or 1985.

428 003 SWAIN CHANNEL, JARVIS THOROFARE, NJ

LOCATION: 38 58 ,74 52
ISLAND SIZE: -
COLONY SIZE: 26
HABITAT: Mainland-marsh
NEST SUBSTRATE: Grass-salt marsh,wrack
OWNERSHIP: Private-Corporation

	--------- 1977	---------		--------- 1985	---------	
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU	6/1	90	AEa	June	1400	AEa
HEGU				June	6	AEa
GBBG				June	2	AEa
COTE	6/1	70	AEa			
FOTE	6/1	200	AEa	June	190	AEa

428 003.1 CRESSE ISLAND, NJ

LOCATION: 38 58 ,74 51
ISLAND SIZE: -
COLONY SIZE: 10
HABITAT: Mainland-marsh-dredge/fill
NEST SUBSTRATE: Shrubs,grass
OWNERSHIP: ?

	--------- 1977	---------		--------- 1985	---------	
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG				June	18	AEa
SNEG				June	120	AEa
LBHE				June	2	AEa
CAEG				June	30	AEa
TCHE				June	4	AEa
BCNH				June	50	AEa
YCNH				June	6	AEa
GLIB				June	125	AEa
HEGU				June	1	AEa

No report for 1977.

428 004 CAPE MAY INLET, NJ

LOCATION: 38 57 ,74 52
ISLAND SIZE: -
COLONY SIZE: 11
HABITAT: Dredge/fill
NEST SUBSTRATE: Trees, shrubs
OWNERSHIP: Public-US Coast Gd.

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
GREG	6/8	3	AEg	Site not used in 1985		
SNEG	6/8	5	AEg			
LBHE	6/8	3	AEg			
BCNH	6/1	100	AEg			
YCNH	6/8	4	AEg			
GLIB	6/21	77	AEg			

428 005 WILDWOOD-2 MILE BEACH, NJ

LOCATION: 38 59 ,74 49
ISLAND SIZE: -
COLONY SIZE: <2
HABITAT: Island-barrier
NEST SUBSTRATE: Sand
OWNERSHIP: Public-US Coast Gd.

	--------- 1977 ---------			--------- 1985 ---------		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LETE	6/3	10	AC	June	2	AC

428 005.1 SOUTHWEST COVE, JARVIS SOUND, NJ

LOCATION: 38 58 ,74 52
ISLAND SIZE: <2
COLONY SIZE: <2
HABITAT: Island-dredge/fill
NEST SUBSTRATE: Sand, grass
OWNERSHIP: ?

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
LAGU				June	4	AEa
COTE				June	400	AEa

No report for 1977.

428 005.2 THOROFARE ISLAND, NJ

LOCATION: 38 57 ,74 52
ISLAND SIZE: 10
COLONY SIZE: <2
HABITAT: Island-marsh
NEST SUBSTRATE: Grass, wrack
OWNERSHIP: ?

	1977			1985		
SPECIES	DATE	NESTING PAIRS	INVENTORY METHOD	DATE	NESTING PAIRS	INVENTORY METHOD
COTE				June	15	AEa

No report for 1977.

Versar INC.
ESM Operations

11 April 1996

Beth Brandreth
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Re: Brigantine commercial surfclam survey

Dear Beth:

The purpose of this letter is to provide the U.S. Army Corps of Engineers further information on surfclam abundances and distributions at four sand borrow sites near Brigantine and Absecon Island, New Jersey, and to provide recommendations as to which sites would have the lowest impact on surfclam populations and commercial harvest.

Background

At your request, I have conducted additional analyses of the results of the commercial surfclam survey Versar conducted for the Corps last summer. Our survey entailed sampling at three stations within each of four borrow sites. The four sites included the Brigantine Inlet Site (Site D), the Absecon Inlet Site (Site A), the Absecon Island Offshore Site (Site B), and the Great Egg Harbor Inlet Site (Site C; see Figure 1). The Corps intends to use the Brigantine Inlet borrow site (Site D) as a source of sand for beach replenishment along Brigantine Island and either Site A, B, or C as a source of sand for beach replenishment on Absecon Island.

The results of last summer's survey showed that surfclam densities were lowest at the Brigantine Inlet borrow site by an order of magnitude. Clam densities at the Brigantine Inlet Site averaged 0.6 clams/m^2 while densities at the three Absecon Island sites ranged from 5.7 to 13.5 clams/m^2 (Table 1). Thus, mining sand from the Brigantine Inlet Site will probably have the least impact on the local surfclam populations.

The selection of a borrow source for Absecon Island among Sites A, B, and C is not as straightforward as densities and number of bushels collected during the surfclam survey were similar. To help select the site that will have the least impact on surfclam populations, we analyzed the length data taken during the survey and created length frequency distribution plots. We also estimated the approximate age structure of the surfclams within each borrow site based on published age and growth studies[1].

Table 1. Results of the Brigantine clam survey conducted on October 25, 1995

Borrow Area	Latitude	Longitude	Station	# of Clams/ Bushel	# of Bushels	Total Clams	Distance Towed (m)	Density (Clams/ m^2)
Brigantine Inlet	39 26.42	74 18.38	D1	172	1.8	303.3	238	0.7
	39 26.58	74 18.26	D3	183	1.1	183.4	194	0.5
	39 26.26	74 18.45	D10	165	1.5	256.5	331	0.4
			Avg #	173.3				0.6
Absecon Inlet	39 21.78	74 23.27	A13	147	22	3182.7	272	6.4
	39 21.82	74 23.12	A14	148	15	2170	249	4.8
	39 21.72	74 23.03	A15	139	23	3327.3	310	5.9
			Avg #	144.7				5.7
Absecon Island Offshore	39 20.56	74 23.98	B22	156	50	7800	307	13.9
	39 20.47	74 23.50	B23	112	37	5772	261	12.1
	39 20.59	74 24.06	B24	200	25	3900	217	9.8
			Avg #	156				11.9
Great Egg Harbor Inlet	39 17.74	74 30.91	C16	235	40	9280	264	19.2
	39 17.64	74 30.99	C17	221	11	2552	173	8.1
	39 17.63	74 31.01	C18	240	13	3016	125	13.2
			Avg #	232				13.5

Results

The results of the length frequency analysis for each borrow site is presented in Figure 2. Approximate length at age is summarized in Table 2. A bimodal size frequency distribution was apparent at the Great Egg Harbor Inlet site (Site C). At this site clams less than 5 and greater than 10 years old dominated the catch. At the offshore site (Site C) 45% of the

[1] Jones, D.S., I. Thompson, and W. Ambrose. 1978. Age and growth rate determinations for the surf clam (Bivalvia: Mactraces), based on internal growth lines in shell cross-sections. Marine Biology 47: 63-70

catch was comprised of 9-10 cm surfclams (approximately 6-7 years old) and few less than 5 and greater than 10 year old individuals were found in the collections. At Site A, near Absecon Inlet, an equal distribution of 5-10 and greater than 10 year old clams were found and few specimens were less than 5 years old.

Table 2. Estimated length (cm) at age for inshore surfclam populations. (Adapted from Jones et al. 1978)

1	3.78
2	5.75
3	7.89
4	8.29
5	9.45
6	9.81
7	10.22
8	10.60
9	10.83
>10	10.94

Recommendations

Because surfclams are abundant throughout the study area and only a relatively small area will be effected by the mining operation (borrow areas A, B, and C range in size from 190 to 345 acres), it is unlikely that population level effects will result from the dredging. Surfclams are distributed in western North Atlantic waters from the southern Gulf of St. Lawrence to Cape Hatteras and commercial concentrations are found primarily off New Jersey. According to NOAA[2] levels of surfclam resources are adequate to support the Middle Atlantic fisheries at or near current levels (18,000 to 23,000 mt of meats). Although population level effects are an unlikely result of the beach replenishment project, the effects of the project on commercial clamming could be minimized by 1) harvesting the

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[2] Northeast Fisheries Science Center. 1993. Report of the 15th Northeast Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA NOAA/NMFS/NEFSC. NEFSC Ref. Doc. 93-06.

clams before mining the sand, and 2) preserving sites with the greatest potential for future harvests and recruitment of seed clams.

Based on the surfclam density and size distribution data, we recommend that the Great Egg Harbor Inlet site (Site C) and the Absecon Island Offshore site (Site B) not be used as a source of material for beach replenishment. The Great Egg Harbor Inlet site had the highest clam density and the largest percentage of younger (and smaller) surfclams. Thus, this site has the greatest potential for increasing harvestable biomass and recruitment of seed clams. The offshore site (Site B) had intermediate clam densities and a large percentage of individuals below the preferred harvest size of 12.5 cm (5 inches). Elimination of this site for beach replenishment projects will allow time for these stocks to increase its value to the shellfish fishery.

We recommend the use of Site A as the source of sand for beach replenishment for Absecon Island. Site A had the lowest clam abundance and was comprised of larger individuals. Because mostly larger individuals exist at this site, the site's future potential for increased harvest biomass is low as most of the clams are near the end of their growth curve. Relative to Site B and C, use of Site A for beach replenishment projects along Absecon Island will probably have the least impact on the shellfish populations and the commercial fishing industry in the area.

Sincerely,

William Burton
Ecological Sciences & Analysis

WB:wb/gl

Enc.

cc: File:3062-012
22\phila\brigan\10837-l

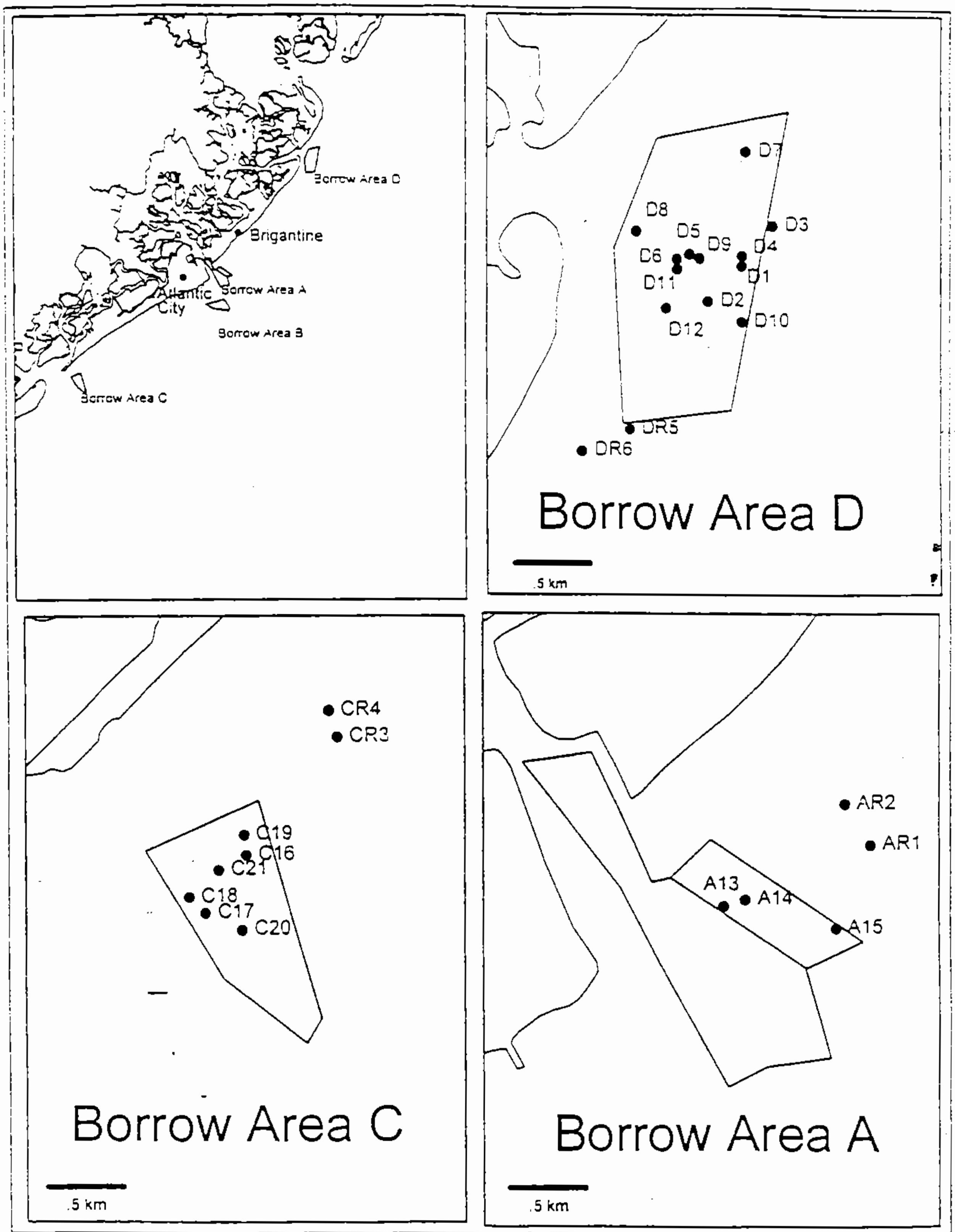

Figure 1. Location of the four borrow areas near Brigantine and Absecon Island

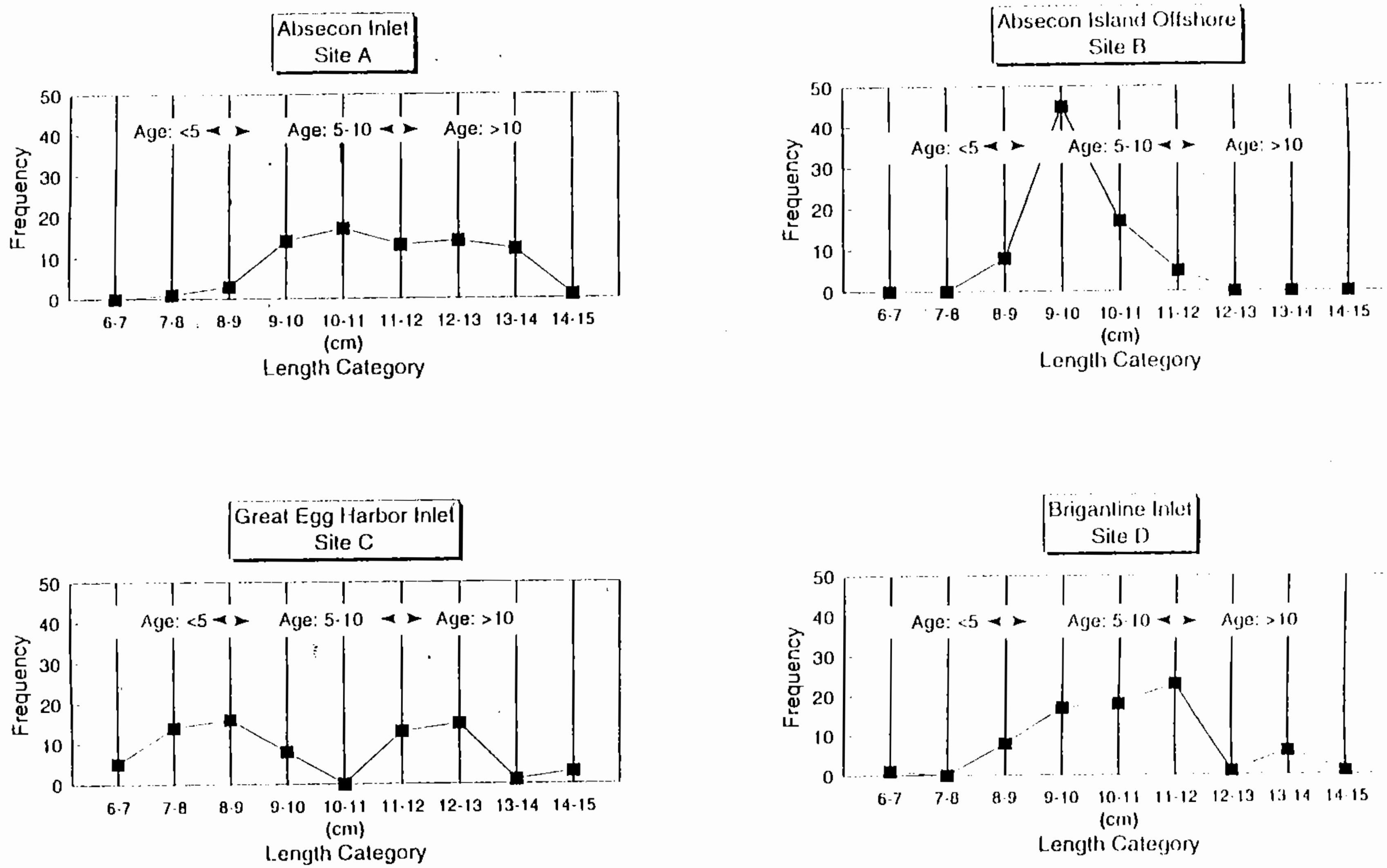

Figure 2. Surfclam length frequency distribution among Sites A, B, C, and D

FINAL REPORT

Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey: Benthic Animal Assessment of Potential Borrow Source

by

Roy K. Kropp
Battelle Ocean Sciences
397 Washington Street
Duxbury, MA 02332

for

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709

February 28, 1995

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13. ABSTRACT (Maximum 200 words)
As part of a broader shore protection study, the U.S. Army Corps of Engineers, Philadelphia District conducted this study of the infaunal benthos at two areas in the vicinity of Absecon Inlet, New Jersey that could serve as sources for materials to be used in beach replenishment activities. Thirty-eight benthic grab samples were collected from these potential borrow areas and reference stations. Samples were analyzed for benthic macrofauna, sediment grain size distribution, and total organic carbon (TOC) content. Sediments within the study area were very sandy. Thirty-six of the stations had sand fractions that exceeded 90 %. TOC levels were above detectable limits at only six stations, ranging from 0.01-0.7 % at those stations. Potential Borrow Area "A" was characterized by relatively low infaunal abundance (mean ≈ 990 individuals/m^2) and low species diversity ($H' \approx 2.0$). Characteristic organisms included haustoriid amphipods, particularly *Acanthohaustorius millsi* and *Protohaustorius* sp. B. The archiannelid worm *Polygordius* was rare in this area. Potential Borrow Area "B" was characterized by relatively high infaunal abundance (mean ≈ 1700 individuals/m^2) and low species diversity ($H' \approx 2.1$). Characteristic organisms included *Polygordius* (mean ≈ 710 individuals/m^2) and *Protohaustorius* sp. B. The Atlantic surfclam, *Spisula solidissima*, was scattered throughout the study area at mean densities of about 10-20 individuals/m^2.

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PURPOSE\OBJECTIVES

The assessment of the benthic communities in the Brigantine Inlet, NJ area is part of a broader study covering about 15 miles of Atlantic Ocean coast in southern New Jersey. Included in the area are two islands, Brigantine and Absecon Islands, which are located in Atlantic County.

The purpose of the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study is to investigate shore protection and hurricane damage problems and to consider potential solutions. The feasibility study is being conducted through a series of two staggered interim studies. The first interim study, which incorporates the present scope of work, includes Absecon Island on which the communities of Atlantic City, Ventnor, Margate, and Longport are located. This interim study includes substantial data collection and analysis to define existing coastal processes and conditions along the entire coast. The second interim study, which is not included in the present scope of work, will include Brigantine Island on which the City of Brigantine and the North Brigantine State Natural Area are located. Brigantine Island is bounded on the north by Brigantine Inlet and on the south by Absecon Inlet. The eastern boundaries of both islands front the Atlantic Ocean; the western margins have extensive coastal and estuarine wetlands. Only the potential borrow sources for the first interim feasibility study and its immediate vicinity will be investigated under the present scope of work. The potential borrow source areas identified for this interim study are located in Absecon Inlet and immediately offshore of Atlantic City.

A critical component of the feasibility study is the evaluation and selection of an offshore sand borrow source for use in beach renourishment activities. The reconnaissance study (USACE, 1992) identified the need to determine whether or not commercially, recreationally, and ecologically important benthic communities were present within the potential borrow sources. The purpose of the present study was to establish baseline conditions of the benthic macroinvertebrate community within the proposed borrow areas and to compare it with benthic communities outside the proposed borrow areas. Also, the presence of any benthic macroinvertebrates of commercial or recreational importance within the potential borrow areas was determined.

Materials and Methods

Sampling Sites

Benthic macroinvertebrates, sediment samples, and water-quality data were collected from two potential borrow areas (termed Potential Borrow Areas A and B) off Atlantic City, NJ (Figures 1 and 2) that were selected by the Philadelphia District Army Corps of Engineers. Potential Borrow Area "A" covers about 269.34 acres and was defined by the following coordinates.

Latitude	Longitude
39°22'35"N	74°24'50" W
39°22'10"N	74°24'24.6" W
39°21'30"N	74°23'56 "W
39°21'34"N	74°23'46 "W
39°21'36"N	74°23'29" W
39°21'56"N	74°23'40" W
39°22'12"N	74°24'11" W
39°22'12"N	74°24'16.5" W
39°22'37"N	74°24'32" W

Within this area 16 stations (Figure 2) were selected randomly by computer. The coordinates for each station are listed in Table 1.

Potential Borrow Area "B" covers about 218.28 acres and was defined by the following coordinates.

Latitude	Longitude
39°20'50"N	74°24'45"W
39°20'39"N	74°24'20"W
39°20'34"N	74°23'32"W
39°20'40"N	74°23'27"W
39°21'01"N	74°23'45"W

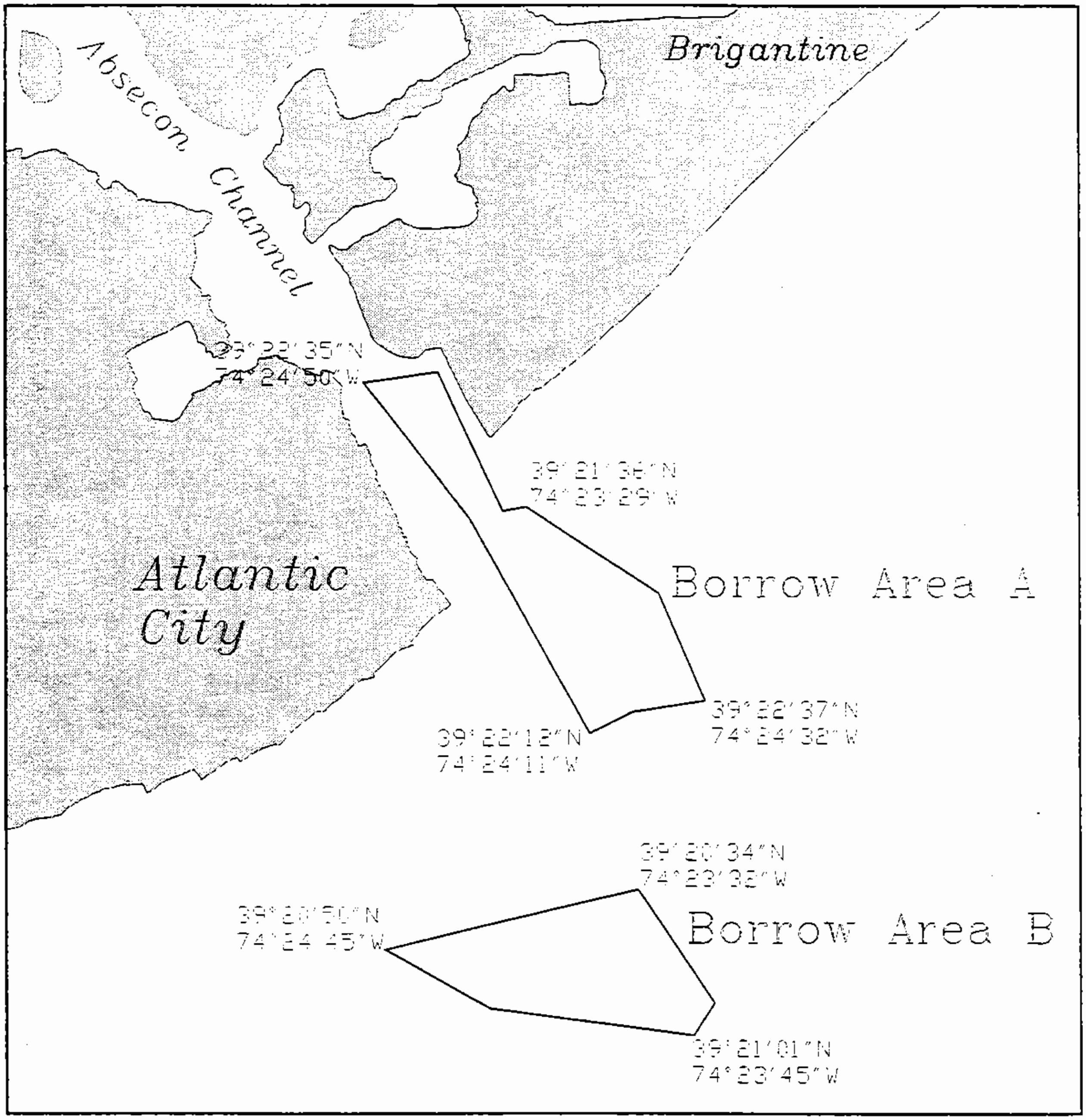

Figure 1. General location of the Absecon Inlet study area.

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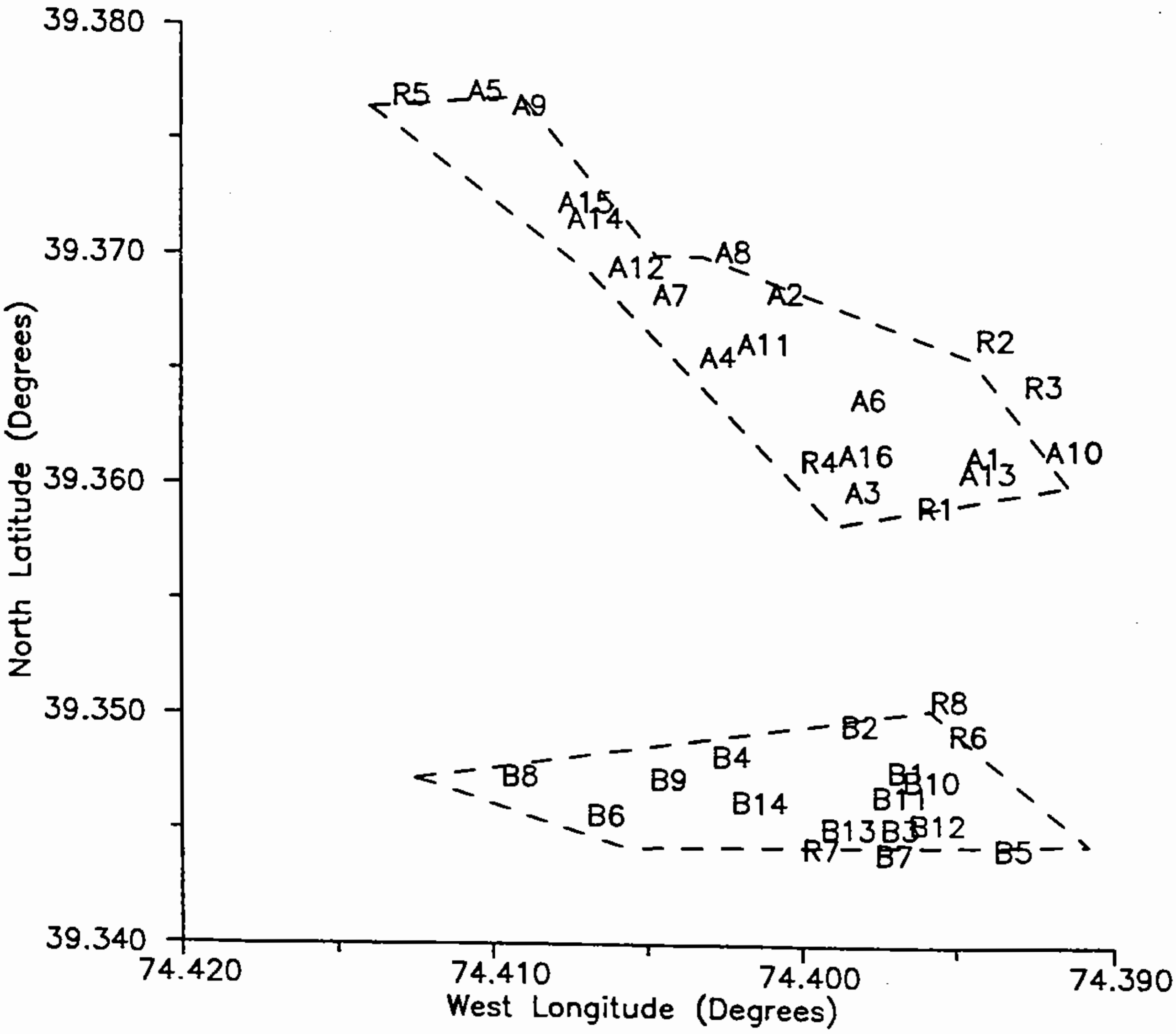

Figure 2. Locations of the sampling stations in the Absecon Inlet study area, 1994.

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Table 1. Station coordinates and depths for sites sampled during the Brigantine Inlet Interim Feasibility study, 1994.

Station	West Longitude	North Latitude	Depth (m)	Station	West Longitude	North Latitude	Depth (m)	Station	West Longitude	North Latitude	Depth (m)
Potential Borrow Area A				Potential Borrow Area B				Reference Sites			
A1	74.3946°	39.3609°	5.8	**B1**	74.3972°	39.3472°	7.6	**R1**	74.3962°	39.3587°	4.8
A2	74.4010°	39.3680°	3.9	**B2**	74.3987°	39.3492°	7.4	**R2**	74.3943°	39.3660°	5.6
A3	74.3985°	39.3594°	7.2	**B3**	74.3974°	39.3447°	6.0	**R3**	74.3928°	39.3640°	6.4
A4	74.4032°	39.3652°	7.1	**B4**	74.4029°	39.3478°	6.7	**R4**	74.4000°	39.3607°	7.0
A5	74.4107°	39.3767°	4.3	**B5**	74.3938°	39.3438°	7.8	**R5**	74.4132°	39.3765°	12.0
A6	74.3983°	39.3634°	5.2	**B6**	74.4069°	39.3452°	9.0	**R6**	74.3952°	39.3488°	9.2
A7	74.4047°	39.3679°	7.6	**B7**	74.3976°	39.3436°	7.4	**R7**	74.4000°	39.3438°	6.5
A8	74.4027°	39.3698°	4.1	**B8**	74.4097°	39.3469°	6.8	**R8**	74.3958°	39.3503°	6.8
A9	74.4092°	39.3761°	4.2	**B9**	74.4049°	39.3468°	7.7				
A10	74.3921°	39.3612°	6.7	**B10**	74.3967°	39.3468°	6.7				
A11	74.4020°	39.3658°	5.4	**B11**	74.3977°	39.3461°	6.5				
A12	74.4061°	39.3691°	7.0	**B12**	74.3965°	39.3449°	6.7				
A13	74.3948°	39.3602°	5.2	**B13**	74.3994°	39.3447°	6.5				
A14	74.4074°	39.3712°	6.8	**B14**	74.4023°	39.3458°	8.2				
A15	74.4077°	39.3719°	5.6								
A16	74.3987°	39.3610°	5.9								

Within this area 14 stations (Figure 2) were selected randomly by computer. The coordinates for each station are listed in Table 1.

Eight "reference" samples were taken from randomly-selected stations adjacent to the borrow areas but within areas that exhibit physical characteristics (i.e., depth and substrate) similar to those of the borrow areas. Five Reference stations were selected from along the perimeter of Potential Borrow Area "A". Three other Reference stations were selected from along the perimeter of Potential Borrow Area "B". The coordinates for each of these Reference stations are given in Table 1.

Navigation

Northstar LORAN/GPS navigation system (15- to 100-m accuracy) was used on board to accurately verify the sampling locations. The actual coordinates of each sampling station were recorded on station log forms.

The navigation system was calibrated at Battelle prior to departure for the survey. At Brigantine, New Jersey, the calibration was checked at the dock before the start and at the completion of each day's sampling activities.

The Battelle Ocean Sampling System (BOSS) acquired data for all on-board electronic sampling systems and navigation systems. The software displayed all of the information once per second on a color monitor and automatically wrote the data to a data file. The navigation portion of the display showed digitized coastlines, navigation aids, sampling statistics, and vessel track. During grab sampling, position fixes were recorded at 2-s intervals. Hard-copy printouts of position fixes were made during grab sampling events or at the start of a hydrocast.

Sample Collection

The survey was conducted October 19-21, 1994 onboard the R/V *Surveysa*. A tide chart for the dates of the survey is provided in Appendix A.

Water/Miscellaneous—Once the survey vessel was on station and coordinates were verified, the vessel was anchored, and water-quality data were collected. An Ocean Sensor OS-100 CTD was used to obtain temperature, salinity, and depth data. The CTD also was equipped with sensors to measure dissolved oxygen (DO; Beckman Module S/N DO sensor) and pH (Innovative Sensors). Data were recorded at a rate of 4 hz during downcast of the CTD package, which was lowered slowly until it contacted the bay bottom.

Sediment—At each station, one sediment sample was collected using a 0.1-m^2 Young-modified Van Veen grab sampler. After collection of the water-quality data, the sediment grab was deployed. Upon retrieval of the grab, the sample was inspected for acceptability. The sample was acceptable if (1) the jaws of the grab were closed properly, (2) the sampler was more than half full, but the sediment did not touch the upper surface, and (3) the surface of the sediment was not significantly disturbed and the sample was even from side-to-side. If the grab was unacceptable, it was emptied, rinsed with filtered seawater and redeployed. If the grab was acceptable, the penetration depth and sediment texture were estimated and recorded. A small subsample was removed for grain-size analysis (see below). The grab was placed over a bucket, the jaws were opened, and filtered seawater was used to gently wash the sample into the bucket.

To provide sediment for grain-size analysis, a standard chemistry scoop was used to extract a small (~150 ml) subsample from each grab. The sediment was transferred to a precleaned sample jar, the subsample properly labeled, and placed immediately in ice filled coolers for storage and transport to shore. On shore the samples were stored over ice (ca. 4 °C). After the survey, samples were returned (in ice filled coolers) to Battelle Ocean Sciences (Duxbury, MA) for shipment to the appropriate subcontractors.

Each sediment sample to be analyzed for benthic infauna was rinsed with filtered seawater over a 0.5-mm-mesh sieve and transferred to a clean, labelled jar. To relax organisms prior to fixation, a magnesium chloride solution (about 7%) was poured into the sample jar to a level that covers the sample material and allowed to sit for about 0.5 h. After that time, a solution of concentrated, buffered, Rose Bengal-stained formaldehyde was added to a final concentration of 10% by volume. After addition of the magnesium chloride and the formaldehyde, the sample jar was turned so that the chemicals mixed to the bottom of the jar. Samples were kept out of the sun during both "relaxation" and after preservation.

Laboratory Analyses

Water Quality—Water-quality data were recorded directly into computer files by the BOSS. Although no subsequent analysis was required, the data were summarized by clump averaging the recorded data.

Sediment Grain Size—Sediment grain-size analysis was performed by GeoPlan Associates according to methods presented in Folk (1974). Briefly, coarse and fine fractions were separated by wet-sieving. The fine fraction (silt and clay) was further separated by suspending the sediment in a deflocculant solution and taking aliquots of the settling sediment at timed intervals after the solution was thoroughly mixed. The coarse fraction (sand and gravel) was dried and then separated by sieving at whole phi intervals. For each station, graphical methods were used to calculate the phi (ϕ) size at the 16th, 50th, and 84th percentiles of the cumulative distribution curve. These values were used to calculate the graphical mean (M_z) and standard deviation (sd) according to the formulae:

$$M_z = \frac{phi16 + phi50 + phi84}{3}$$

and,

$$sd = \frac{phi84 - phi16}{2}$$

Grain size was reported as percentage (based on dry weight) of each fraction (gravel, sand, and mud) of the total sample weight.

Total Organic Carbon (TOC)—Global Geochemistry Corporation used a LECO model 761-100 carbon analyzer to determine the TOC content of solid samples. The principle of operation was the high-temperature conversion of all carbon in the treated sample to carbon dioxide in the presence of oxygen. The carbon dioxide was then quantified by thermal conductivity detection.

TOC data were reported as percent dry-weight. Prior to analysis the sample was treated with 6N HCL to remove inorganic carbon.

Macrofauna—Sample analyses were conducted by Barry Vittor and Associates (BVA), Mobile, AL. Prior to being sorted, samples were rinsed with fresh water and transferred to 70% ethanol for storage. All intact macrofaunal species and body fragments identifiable to species level were removed from each sample. Dead bivalves (hinged shells and intact single valves) of commercial value (e.g., *Ensis, Tagelus, Spisula, Mercenaria*) were removed from the sample debris and counted. Appropriate quality control procedures were followed.

Identification of all specimens was to the species level whenever possible. Juveniles or damaged specimens lacking the characters necessary for identification to species were identified to the next highest taxonomic level. Specimens that were counted had a critical part of its body present; for example, polychaetes and arthropods had the head, bivalves the umbo, and sea stars more than one-half the central disc present. Animals lacking these parts were considered fragments and not counted as part of the sample. Epifauna attached to shell fragments, pelagic contaminants, and pieces of colonial organisms were noted as present, but not counted. Each identified taxon was placed in its own labeled vial and stored.

The animals in each taxonomic unit were measured and placed into one of two categories, greater than or equal to, or less than 2 cm in length. If individuals were fragmented, the length was approximated.

The wet-weight biomass of each major taxonomic category (Annelida, Arthropoda, Mollusca, Miscellaneous) was determined to 1-mg accuracy by using a calibrated electronic balance. Prior to weighing each taxon, the specimen was placed on absorbent paper toweling to blot dry. In an effort to obtain consistent weights, specimens were blot-dried for 2 min. However, the time required for blot-drying may have been less for small (e.g., amphipods), less numerous taxa. For larger taxa (e.g., hard clams), the shell was opened and water was drained before weighing.

A reference collection of each taxonomic unit was provided by BVA for presentation to the Philadelphia District Army Corps of Engineers. For this collection, a suitable representative (or representatives) of each taxonomic unit was placed in a properly labeled container containing 70% ethanol.

Macrofaunal Data Analysis

Calculations of numbers of species per sample, diversity, evenness, and dominance per sample, and similarity analyses included only taxa identified to species with two exceptions. Two taxa, Oligochaeta and *Polygordius* sp., although not identified to species were included in these analyses. The former was included because of its importance in early colonization, the latter because it is likely only one species. Other analyses, e.g., total and major taxon abundance, included all taxa collected.

Prior to starting faunal data analyses, the data set was scanned quickly to identify species or taxa that were predominant throughout the study area or in one of the potential borrow areas. These taxa were selected for individual analysis. Species selected were *Polygordius* (an archiannelid), *Magelona papillicornis* (a magelonid polychaete), *Scolelepis squamata* (a spionid polychaete), and *Spisula solidissima* (a bivalve mollusc). Three haustoriid amphipod species, *Acanthohaustorius millsi, Protohaustorius* sp. B, and *Parahaustorius longimerus*, also were chosen for individual analysis. More inclusive taxa selected were, oligochaete worms, capitellid polychaetes, and haustoriid amphipods.

To help characterize the community, descriptive ecological measures—the Shannon Diversity Index (H'), Pielou's evenness (J'), and Simpson's Dominance Index (λ)—were calculated using standard formulae (see Ludwig and Reynolds, 1988). The Shannon index, which is based on information theory, estimates the uncertainty of predicting the identity of an individual chosen at random from a sample. This uncertainty increases as the number of species in a sample increases and as the individuals in a sample become evenly allocated among the species. H' would have a value of 0 if there was only one species in a sample and would be at a maximum when all species in the sample have the same number of individuals. In practice, values of H' range from < 1 to just greater than 6. Evenness (J') is an indication of the relative abundance of species. J' is calculated as the proportion between the measured Shannon diversity value for a sample and the maximum diversity value possible if the number of individuals in the sample were evenly distributed among the species. J' is at a maximum (1.0) when all species present are equally abundant. Simpson's Dominance Index, more properly known as Simpson's Diversity Index, estimates the likelihood that two individuals selected at random from the same sample belong to the same species. The index, which reaches a maximum of 1.0 when all individuals present in a sample belong to the same species, is calculated as the sum of the squared proportional abundance of each species in the sample. When community diversity is low, the Simpson Index is high.

The program PRARE1, written in 1972 by George Power for H. Sanders and F. Grassle at Woods Hole Oceanographic Institute and modified for the VAX in 1982 by T. Danforth, was used to calculate H', J' and λ. The spreadsheet program Quattro® Pro for Windows, version 5.0 (Borland, 1993) was used to produce graphs and to perform calculations of means, standard deviations, confidence intervals, and Pearson correlation coefficients (r). Similarity analyses were conducted on untransformed abundance data using the Bray-Curtis algorithm (Bray and Curtis, 1957). The Bray-Curtis measure commonly is used in marine ecological studies and is strongly influenced by very abundant taxa (Boesch, 1977; Beals, 1984). Clustering was accomplished with the unweighted pair-groups method using arithmetic averages (UPGMA; Sneath and Sokal, 1973; Gauch, 1982). The results are presented as dendrograms.

RESULTS

Water Quality

The near-bottom water-quality parameters measured, temperature, salinity, dissolved oxygen and pH varied little throughout the Brigantine Inlet study area. Near-bottom temperature ranged from 15.1-15.9 °C, salinity from 31.4-31.7 ‰, and pH from 8.0-8.2 (Table 2). Near-bottom dissolved oxygen ranged from 6.8-7.7 mg/L at stations in Potential Borrow Area "A" and from 6.0-7.6 mg/L in Potential Borrow Area "B" (Table 2). Water-quality values among the Reference stations were similar to those obtained from the potential borrow areas (Table 2). Complete water-quality data are listed in Appendix B.

Table 2. Near-bottom water-quality data collected during the Brigantine Inlet Interim Feasibility study, 1994.

Station	Temp (° C)	Salinity (‰)	DO (mg/L)	pH	Station	Temp (° C)	Salinity (‰)	DO (mg/L)	pH	Station	Temp (° C)	Salinity (‰)	DO (mg/L)	pH
A1	15.7	31.5	6.8	8.0	**B1**	15.7	31.6	6.7	8.0	**R1**	15.2	31.5	7.1	8.1
A2	15.6	31.5	6.9	8.2	**B2**	15.7	31.6	6.7	8.0	**R2**	15.6	31.6	6.8	8.0
A3	15.6	31.6	6.8	8.1	**B3**	15.3	31.6	6.8	8.0	**R3**	15.6	31.6	7.1	8.0
A4	15.6	31.5	6.8	8.2	**B4**	15.7	31.6	6.0	8.0	**R4**	15.6	31.6	7.0	8.1
A5	15.7	31.4	7.7	8.1	**B5**	15.7	31.6	6.4	8.0	**R5**	15.7	31.4	7.4	8.1
A6	15.6	31.6	6.9	8.1	**B6**	15.9	31.7	7.3	8.1	**R6**	15.8	31.6	6.4	8.0
A7	15.6	31.5	7.0	8.1	**B7**	15.6	31.6	6.7	8.0	**R7**	15.6	31.6	6.9	8.0
A8	15.6	31.6	6.9	8.1	**B8**	15.8	31.6	6.3	8.1	**R8**	15.8	31.6	6.7	8.0
A9	15.8	31.4	6.9	8.1	**B9**	15.8	31.6	6.3	8.0					
A10	15.5	31.6	6.9	8.1	**B10**	15.9	31.5	7.6	8.2					
A11	15.6	31.5	6.9	8.2	**B11**	15.8	31.5	6.9	8.0					
A12	15.6	31.6	6.9	8.1	**B12**	15.7	31.5	6.6	8.0					
A13	15.1	31.5	6.9	8.1	**B13**	15.6	31.6	6.6	8.0					
A14	15.6	31.6	6.9	8.1	**B14**	15.8	31.6	6.8	8.0					
A15	15.5	31.6	6.9	8.1										
A16	15.6	31.5	7.0	8.1										

Sediments

Grain Size—Cumulative distribution plots of sediment grain size at each station are presented in Appendix C. Sediments throughout the study area were very sandy. The sand fraction ranged from 82.1 to 99.8 percent dry weight in Potential Borrow Area "A", 73.4 to 99.9 percent dry weight in Potential Borrow Area "B", and from 90.6 to 99.9 percent dry weight among the Reference stations (Table 3). Two stations had substantial gravel fractions—Station A-9 (17.7%) and Station R-5 (9.3%). Station B-6 had a relatively high silt content (21.7%). The numerical mean phi ranged from 1.66 to 2.88 in Potential Borrow Area "A", from 1.68 to 3.95 in Potential Borrow Area "B", and from 1.67 to 2.97 among the Reference stations (Table 3). The range of the graphic mean within each area (Table 4) was similar to, but slightly lower than that of the numerical mean. Sediments with Potential Borrow Area "A" varied from very poorly sorted at Station A-9 to very well sorted at three stations (Table 4). Within Potential Borrow Area "B" sediments varied from moderately well sorted to very well sorted. Sediments at Station R-5 were poorly sorted, whereas those at the remaining Reference stations were moderately well sorted to well sorted.

TOC—Sediment TOC levels were very low throughout the study area. TOC exceeded the detection limits (0.005%) at only six stations: Station A-6 (0.01%), Station B-2 (0.02%), Station B-6 (0.73%), Station B-9 (0.01%), Station R-5 (0.35%), and Station R-8 (0.05%).

Macrofaunal Communities

In this section, for all instances where a mean value is presented, the 95% confidence intervals are provided parenthetically. The actual location of one of the intended Reference stations, Station R-4, was within Potential Borrow Area "A" (Figure 2).

Abundance—Total macrofaunal abundance per station in Potential Borrow Area "A" ranged from 19-20 individuals/0.1 m^2 at three stations to 260 individuals/0.1 m^2 at Station A-16 (Figure 3, Table 5). Mean total abundance within Potential Borrow Area "A" was 99 ($\pm$ 36) individuals/0.1 m^2. The relative contribution of the major taxonomic groups varied within this area. Arthropods were the predominant component of the total macrofaunal abundance at 13 stations, contributing about 67% (Station A-16) to 94% (Station A-12) of the individuals present

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Table 3. Sediment percent composition and numerical mean statistics at stations in the Absecon Inlet study area, 1994.

Station	% Gravel	% Sand	% Silt	% Clay	Phi Percent (by weight) <-1	0	1	2	3	4	Numerical Mean	Std Dev
A-1	0.1	99.7	0.1	0.1	0.08	0.05	0.54	1.01	77.48	20.64	2.69	0.52
A-2	0.0	99.8	0.1	0.1	0.00	0.03	0.29	0.84	76.59	22.04	2.72	0.50
A-3	0.4	99.5	0.1	0.1	0.38	0.08	1.34	16.42	79.43	2.22	2.32	0.56
A-4	0.0	99.8	0.1	0.1	0.00	0.00	0.15	9.99	88.56	1.08	2.42	0.41
A-5	0.4	99.4	0.1	0.1	0.39	0.56	8.72	32.98	54.36	2.76	2.00	0.79
A-6	0.0	99.8	0.1	0.1	0.00	0.06	0.04	1.37	81.45	16.89	2.66	0.46
A-7	0.0	99.8	0.1	0.1	0.00	0.00	0.09	2.76	93.93	3.04	2.51	0.35
A-8	0.0	99.8	0.1	0.1	0.00	0.03	0.05	2.12	87.28	10.31	2.59	0.42
A-9	17.7	82.1	0.1	0.1	17.74	1.27	4.62	5.79	65.38	5.02	1.66	1.61
A-10	0.1	98.2	0.8	0.8	0.14	0.15	0.89	2.53	59.43	35.20	2.88	0.87
A-11	0.0	99.8	0.1	0.1	0.00	0.02	0.08	0.65	85.01	14.04	2.64	0.43
A-12	0.1	99.8	0.1	0.1	0.11	0.18	0.32	15.90	82.28	1.07	2.34	0.48
A-13	0.0	99.7	0.1	0.1	0.03	0.06	0.73	2.42	70.38	26.13	2.73	0.58
A-14	1.7	98.2	0.1	0.1	1.69	0.77	6.88	46.02	43.92	0.56	1.83	0.82
A-15	0.6	99.2	0.1	0.1	0.63	0.37	2.00	39.67	56.19	0.95	2.05	0.68
A-16	0.0	99.8	0.1	0.1	0.00	0.04	0.17	1.12	70.55	27.95	2.77	0.52
B-1	0.0	99.9	0.1	0.0	0.00	0.71	3.99	42.17	51.40	1.60	2.00	0.66
B-2	0.1	98.9	0.8	0.3	0.06	0.04	0.08	0.21	42.37	56.21	3.10	0.65
B-3	0.0	99.8	0.1	0.1	0.00	0.15	0.38	12.99	82.95	3.30	2.40	0.50
B-4	0.2	99.6	0.1	0.1	0.21	0.07	0.52	3.17	50.79	45.02	2.91	0.66
B-5	0.0	99.8	0.1	0.1	0.03	0.13	0.76	9.88	62.83	26.22	2.65	0.65
B-6	0.0	73.4	21.7	4.9	0.00	0.12	0.63	1.03	31.58	40.04	3.95	1.75
B-7	0.1	99.8	0.1	0.1	0.05	0.13	3.05	42.35	50.07	4.22	2.06	0.67
B-8	0.2	99.4	0.4	0.1	0.16	0.08	0.08	0.54	56.57	42.11	2.92	0.60
B-9	0.0	99.8	0.1	0.1	0.02	0.02	0.07	0.21	44.80	54.72	3.05	0.54
B-10	0.0	99.7	0.1	0.1	0.05	0.02	1.92	79.82	16.92	1.07	1.68	0.53
B-11	0.0	99.8	0.1	0.1	0.02	0.02	1.08	14.85	82.94	0.90	2.35	0.48
B-12	0.0	99.8	0.1	0.1	0.00	0.02	0.25	10.60	78.85	10.08	2.50	0.52
B-13	0.0	99.8	0.1	0.1	0.03	0.27	1.28	16.18	80.73	1.37	2.32	0.51
B-14	0.3	99.6	0.1	0.1	0.27	0.56	6.88	24.13	65.83	2.15	2.12	0.73
R-1	0.0	99.7	0.1	0.1	0.02	0.05	0.11	0.18	74.95	24.43	2.75	0.52
R-2	2.1	97.8	0.1	0.1	2.06	0.50	5.55	6.38	57.48	27.85	2.52	0.99
R-3	0.0	99.8	0.1	0.1	0.03	0.08	0.62	2.87	55.91	40.32	2.87	0.62
R-4	0.0	99.9	0.1	0.1	0.00	0.06	0.06	0.40	79.94	19.41	2.69	0.45
R-5	9.3	90.6	0.1	0.1	9.26	3.52	12.21	6.49	66.71	1.65	1.74	1.35
R-6	0.2	99.6	0.1	0.1	0.20	1.34	12.97	62.87	12.69	9.69	1.67	0.88
R-7	0.0	99.8	0.1	0.1	0.00	0.04	1.05	3.62	87.28	7.83	2.53	0.46
R-8	0.0	99.8	0.1	0.1	0.00	0.04	0.56	1.63	48.25	49.35	2.97	0.60

Table 4. Sediment graphical mean statistics and sorting at stations in the Absecon Inlet study area, 1994.

	Graphic	Standard			Percentile	
Station	Mean	Deviation	Sorting*	Phi 16	Phi 50	Phi 84
A-1	2.55	0.35	WS	2.4	2.7	3.1
A-2	2.60	0.35	WS	2.4	2.8	3.1
A-3	2.10	0.40	WS	1.9	2.3	2.7
A-4	2.25	0.25	VWS	2.1	2.4	2.6
A-5	1.70	0.65	MWS	1.3	2.1	2.6
A-6	2.55	0.30	VWS	2.4	2.7	3.0
A-7	2.35	0.30	VWS	2.2	2.5	2.8
A-8	2.50	0.30	VWS	2.3	2.7	2.9
A-9	0.15	2.30	VPS	-1.9	2.2	2.7
A-10	2.65	0.50	WS	2.4	2.9	3.4
A-11	2.55	0.30	VWS	2.4	2.7	3.0
A-12	2.15	0.30	VWS	2.0	2.3	2.6
A-13	2.60	0.40	WS	2.4	2.8	3.2
A-14	1.85	0.35	WS	1.7	2.0	2.4
A-15	1.85	0.45	WS	1.6	2.1	2.5
A-16	2.60	0.40	WS	2.4	2.8	3.2
B-1	1.75	0.55	MWS	1.4	2.1	2.5
B-2	2.90	0.35	WS	2.7	3.1	3.4
B-3	2.20	0.35	WS	2.0	2.4	2.7
B-4	2.70	0.50	WS	2.4	3.0	3.4
B-5	2.45	0.50	WS	2.2	2.7	3.2
B-6	3.05	0.85	MS	2.7	3.4	4.4
B-7	1.95	0.55	MWS	1.5	2.4	2.6
B-8	2.70	0.40	WS	2.5	2.9	3.3
B-9	2.90	0.35	WS	2.7	3.1	3.4
B-10	1.55	0.35	WS	1.4	1.7	2.1
B-11	2.15	0.30	VWS	2.0	2.3	2.6
B-12	2.30	0.40	WS	2.1	2.5	2.9
B-13	2.15	0.30	VWS	2.0	2.3	2.6
B-14	1.80	0.60	MWS	1.4	2.2	2.6
R-1	2.65	0.35	WS	2.5	2.8	3.2
R-2	2.40	0.55	MWS	2.1	2.7	3.2
R-3	2.65	0.45	WS	2.4	2.9	3.3
R-4	2.60	0.35	WS	2.4	2.8	3.1
R-5	1.25	1.15	PS	0.3	2.2	2.6
R-6	1.35	0.65	MWS	1.1	1.6	2.4
R-7	2.40	0.35	WS	2.2	2.6	2.9
R-8	2.75	0.40	WS	2.5	3.0	3.3

*Sorting Codes:

VWS: Very Well Sorted
WS: Well Sorted
MWS: Moderately Well Sorted
MS: Moderately Sorted
PS: Poorly Sorted
VPS: Very Poorly Sorted

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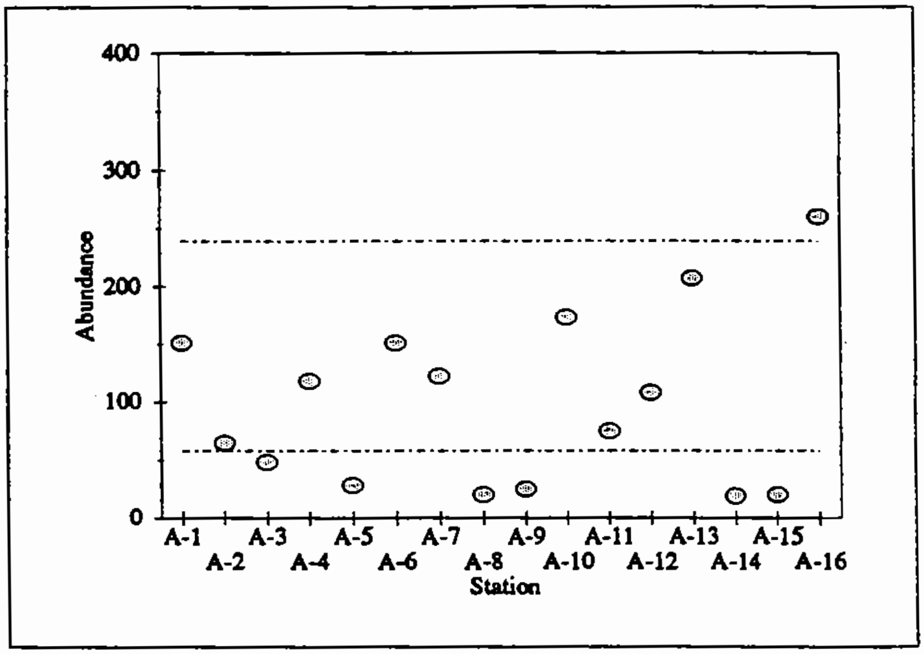

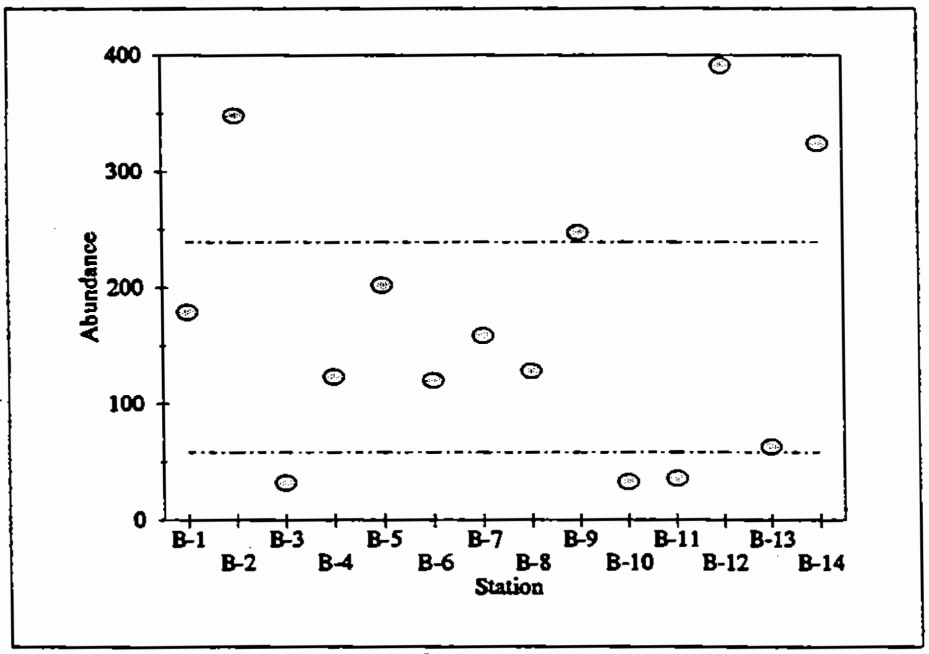

Figure 3. Macrofaunal abundance (#/0.1 m^2) at Potential Borrow Area "A" (top) and "B" (bottom) stations in relation to the range of values found at all reference stations (dashed lines) in the Absecon Inlet study area, 1994.

Table 5. Abundance (#/0.1 m^2) and percent contribution of major taxonomic groups in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

	Abundance					Percent contribution		
Station	Total	Annelids	Arthropods	Molluscs	Misc.	Annelids	Arthropods	Molluscs
A-1	151	26	117	7	1	17.22%	77.48%	4.64%
A-2	65	5	58	1	1	7.69%	89.23%	1.54%
A-3	48	6	41	0	1	12.50%	85.42%	0.00%
A-4	118	11	104	3	0	9.32%	88.14%	2.54%
A-5	28	1	21	6	0	3.57%	75.00%	21.43%
A-6	151	23	125	0	3	15.23%	82.78%	0.00%
A-7	122	6	107	9	0	4.92%	87.70%	7.38%
A-8	20	10	8	2	0	50.00%	40.00%	10.00%
A-9	25	13	8	3	1	52.00%	32.00%	12.00%
A-10	173	29	143	0	1	16.76%	82.66%	0.00%
A-11	75	10	63	1	1	13.33%	84.00%	1.33%
A-12	108	2	102	4	0	1.85%	94.44%	3.70%
A-13	207	17	184	1	5	8.21%	88.89%	0.48%
A-14	19	9	7	0	3	47.37%	36.84%	0.00%
A-15	20	0	16	0	4	0.00%	80.00%	0.00%
A-16	260	23	174	60	3	8.85%	66.92%	23.08%
Mean	99	12	80	6	2			
STDS	74	9	60	15	2			
95% CI	36	4	30	7	1			
B-1	179	150	10	18	1	83.80%	5.59%	10.06%
B-2	348	123	118	104	3	35.34%	33.91%	29.89%
B-3	32	13	6	13	0	40.63%	18.75%	40.63%
B-4	123	43	71	5	4	34.96%	57.72%	4.07%
B-5	202	107	49	44	2	52.97%	24.26%	21.78%
B-6	120	95	7	17	1	79.17%	5.83%	14.17%
B-7	159	112	19	28	0	70.44%	11.95%	17.61%
B-8	128	42	54	30	2	32.81%	42.19%	23.44%
B-9	247	66	76	103	2	26.72%	30.77%	41.70%
B-10	33	20	4	8	1	60.61%	12.12%	24.24%
B-11	36	25	5	4	2	69.44%	13.89%	11.11%
B-12	391	287	55	46	3	73.40%	14.07%	11.76%
B-13	63	42	11	9	1	66.67%	17.46%	14.29%
B-14	324	309	4	11	0	95.37%	1.23%	3.40%
Mean	170	102	35	31	2			
STDS	119	93	36	33	1			
95% CI	63	49	19	17	1			
R-1	128	10	90	25	3	7.81%	70.31%	19.53%
R-2	239	39	183	12	5	16.32%	76.57%	5.02%
R-3	199	31	134	34	0	15.58%	67.34%	17.09%
R-4	132	16	82	32	2	12.12%	62.12%	24.24%
R-5	156	100	11	40	5	64.10%	7.05%	25.64%
R-6	58	53	2	2	1	91.38%	3.45%	3.45%
R-7	106	67	24	13	2	63.21%	22.64%	12.26%
R-8	206	24	104	78	0	11.65%	50.49%	37.86%
Mean	153	43	79	30	2			
STDS	59	30	63	23	2			
95% CI	41	21	44	16	1			

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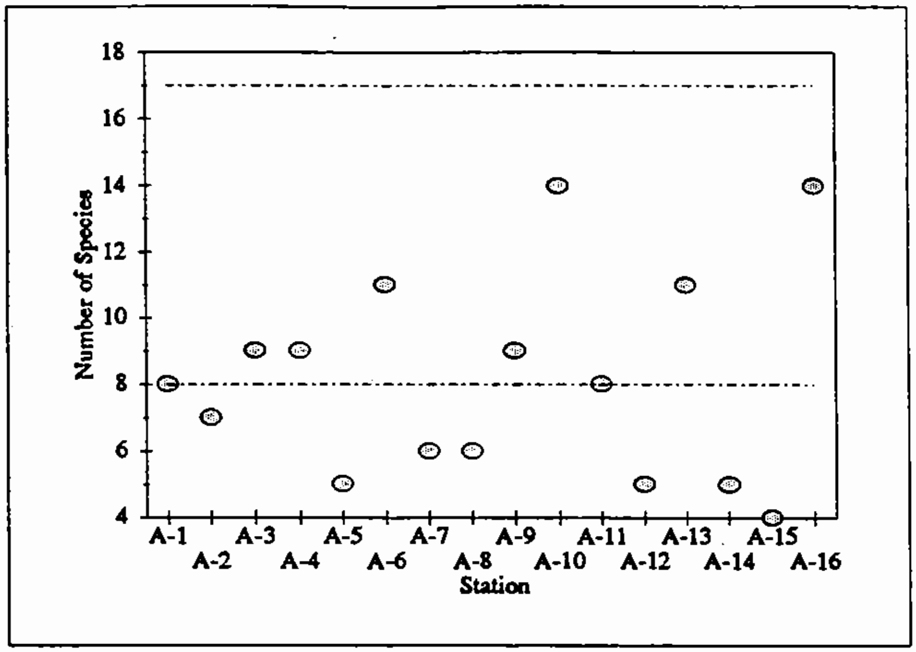
at those stations (Table 5). Annelid worms were the most numerous major taxon at three stations, contributing about 47% (Station A-14) to 52% (Station A-9) of the individuals present at those stations (Table 5). The contribution made by molluscs to total infaunal abundance in Potential Borrow Area "A" was relatively small, ranging from < 1% at six stations to about 23% at Station A-16.

In Potential Borrow Area "B", total macrofaunal abundance ranged from 32-33 individuals/0.1 m^2 at Stations B-3 and B-10 to 391 individuals/0.1 m^2 at Station B-12 (Figure 3, Table 5). Mean total abundance within Potential Borrow Area "B" was 170 (± 63) individuals/0.1 m^2. Annelid worms were the most numerous component of the total macrofaunal abundance at ten stations, contributing about 35% (Station B-2) to 95% (Station B-14) of the individuals present at those stations (Table 5). Arthropods were the most numerous major taxon at Stations B-4 and B-8 (respectively contributing 58% and 42% of the individuals present there). Molluscs were the most numerous major taxon at Station B-9 (contributing 42% of the individuals present there).

Infaunal abundance among the Reference stations ranged from 58 individuals/0.1 m^2 at Station R-6 to 239 individuals/0.1 m^2 at Station R-2 (Table 5). Mean total abundance among the Reference stations was 153 (± 41) individuals/0.1 m^2. Arthropods were the predominant major taxon at five Reference stations, contributing about 50% (Station R-8) to 77% (Station R-2) of the individuals present at those stations. Annelids were the most numerous taxon at three Reference stations, contributing from 63% (Station R-7) to 91% (Stations R-6).

Numbers of Species—The total number of species per sample in Potential Borrow Area "A" ranged from 4 at Station A-15 to 14 at Stations A-10 and A-16 (Figure 4, Table 6). The mean number of species in Potential Borrow Area "A" was 8 (± 2) species per station. At ten stations the number of arthropod species was greater than that of any other major taxon, ranging from 55% (Stations A-6) to 100% (Station A-15) of the total species identified at those stations. At six stations the number of annelid species was greater than that of any other major taxon, ranging from 50% (Stations A-8 and A-11) to 80% (Station A-14) of the total species identified there.



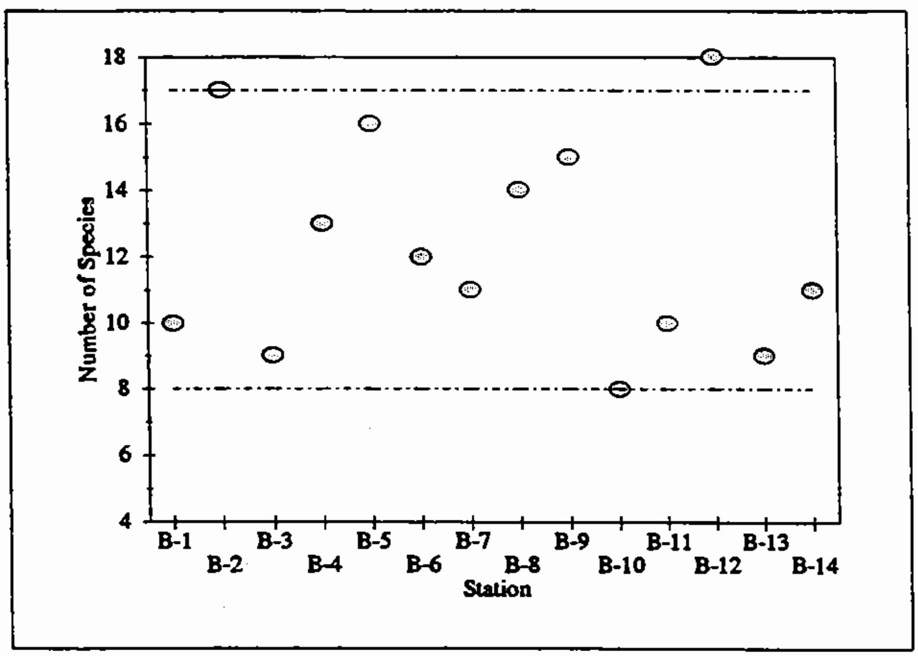


Figure 4. Macrofaunal species numbers at Potential Borrow Area "A" (top) and "B" (bottom) stations in relation to the range of values found at all Reference stations (dashed lines) in the Absecon Inlet study area, 1994.

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Table 6. Number of species and percent contribution of major taxonomic groups in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

		Number of Species				Percent contribution		
Station	Total	Annelids	Arthropods	Molluscs	Misc.	Annelids	Arthropods	Molluscs
A-1	8	4	2	2	0	50.00%	25.00%	25.00%
A-2	7	2	4	1	0	28.57%	57.14%	14.29%
A-3	9	3	6	0	0	33.33%	66.67%	0.00%
A-4	9	3	5	1	0	33.33%	55.56%	11.11%
A-5	5	0	4	1	0	0.00%	80.00%	20.00%
A-6	11	5	6	0	0	45.45%	54.55%	0.00%
A-7	6	1	4	1	0	16.67%	66.67%	16.67%
A-8	6	3	2	1	0	50.00%	33.33%	16.67%
A-9	9	5	2	1	1	55.56%	22.22%	11.11%
A-10	14	10	4	0	0	71.43%	28.57%	0.00%
A-11	8	4	3	1	0	50.00%	37.50%	12.50%
A-12	5	0	4	1	0	0.00%	80.00%	20.00%
A-13	11	4	7	0	0	36.36%	63.64%	0.00%
A-14	5	4	1	0	0	80.00%	20.00%	0.00%
A-15	4	0	4	0	0	0.00%	100.00%	0.00%
A-16	14	5	8	1	0	35.71%	57.14%	7.14%
Mean	8.2	3.3	4.1	0.7	0.1			
STDS	3.1	2.5	1.9	0.6	0.3			
95% CI	1.5	1.2	0.9	0.3	0.1			
B-1	10	4	4	2	0	40.00%	40.00%	20.00%
B-2	17	10	5	2	0	58.82%	29.41%	11.76%
B-3	9	3	4	2	0	33.33%	44.44%	22.22%
B-4	13	8	3	2	0	61.54%	23.08%	15.38%
B-5	16	9	5	2	0	56.25%	31.25%	12.50%
B-6	12	8	3	1	0	66.67%	25.00%	8.33%
B-7	11	5	4	2	0	45.45%	36.36%	18.18%
B-8	14	6	5	3	0	42.86%	35.71%	21.43%
B-9	15	8	4	3	0	53.33%	26.67%	20.00%
B-10	8	3	3	2	0	37.50%	37.50%	25.00%
B-11	10	4	4	2	0	40.00%	40.00%	20.00%
B-12	18	8	8	2	0	44.44%	44.44%	11.11%
B-13	9	2	5	2	0	22.22%	55.56%	22.22%
B-14	11	4	4	3	0	36.36%	36.36%	27.27%
Mean	12.4	5.9	4.4	2.1	0.0			
STDS	3.2	2.6	1.3	0.5	0.0			
95% CI	1.7	1.4	0.7	0.3				
R-1	11	4	4	3	0	36.36%	36.36%	27.27%
R-2	14	6	5	3	0	42.86%	35.71%	21.43%
R-3	13	4	4	5	0	30.77%	30.77%	38.46%
R-4	9	1	6	2	0	11.11%	66.67%	22.22%
R-5	17	8	5	4	0	47.06%	29.41%	23.53%
R-6	8	6	1	1	0	75.00%	12.50%	12.50%
R-7	13	4	6	3	0	30.77%	46.15%	23.08%
R-8	13	7	4	2	0	53.85%	30.77%	15.38%
Mean	12.3	5.0	4.4	2.9	0.0			
STDS	2.9	2.2	1.6	1.2	0.0			
95% CI	2.0	1.5	1.1	0.9				

The total number of species per sample in Potential Borrow Area "B" ranged from 8 at Station B-10 to 18 at Station B-12 (Figure 4, Table 6). The mean number of species in Potential Borrow Area "B" was 12 (± 2) species per station. The number of annelid species was greater than that of any other major taxon at seven stations, ranging from 43% (Station B-8) to 67% (Station B-6) of the total species identified at those stations. At five stations, annelids and arthropods tied as the taxa having the most species identified (Table 6).

The total number of species per sample among the Reference stations ranged from 8 at Station R-6 to 17 at Station R-5 (Table 6). The mean number of species at the Reference stations was 12 (± 2) species per station. Either annelid or arthropod species were more numerous than other major taxa at seven of the eight Reference stations. More mollusc species were found at Reference station R-3 than those of other major taxa.

Community Indices—Species diversity (*H'*) at stations in Potential Borrow Area "A" was moderately low, ranging from 1.35 at Station A-5 to 2.95 at Station A-9 (Figure 5, Table 7). The mean species diversity in Potential Borrow Area "A" was 2.01 (± 0.21). Evenness (*J'*) at stations in Potential Borrow Area "A" ranged from 0.38 at Station A-10 to 0.94 at Station A-8 (Figure 5, Table 7). The mean *J'* for the area was 0.70 (± 0.08). Simpson's Index (λ) in Potential Borrow Area "A" was low, ranging from 0.10 to 0.59 (Table 7). The mean λ for the area was 0.32 (± 0.06).

Species diversity (*H'*) at stations in Potential Borrow Area "B" was similar to that at stations in Potential Borrow Area "A", ranging from 0.87 at Station B-14 to 2.84 at Station B-6 (Figure 5, Table 7). The mean species diversity in Potential Borrow Area "B" was 2.14 (± 0.32). Evenness (*J'*) at stations in Potential Borrow Area "B" ranged from 0.25 at Station B-14 to 0.86 at Station B-3 (Figure 5, Table 7). The mean *J'* for the area was 0.60 (± 0.09). Simpson's Index (λ) in Potential Borrow Area "B" was relatively low, ranging from 0.16 to 0.77 (Table 6). The mean for the area was 0.36 (± 0.10).

Species diversity (*H'*) at stations among the Reference stations was similar to that among borrow area stations, ranging from 1.74 at Station R-6 to 2.87 at Station R-5 (Table 7). The mean species diversity among the Reference stations was 2.26 (± 0.29). Evenness (*J'*) at stations among the Reference stations varied little, ranging from 0.50 at Station R-8 to 0.76 at

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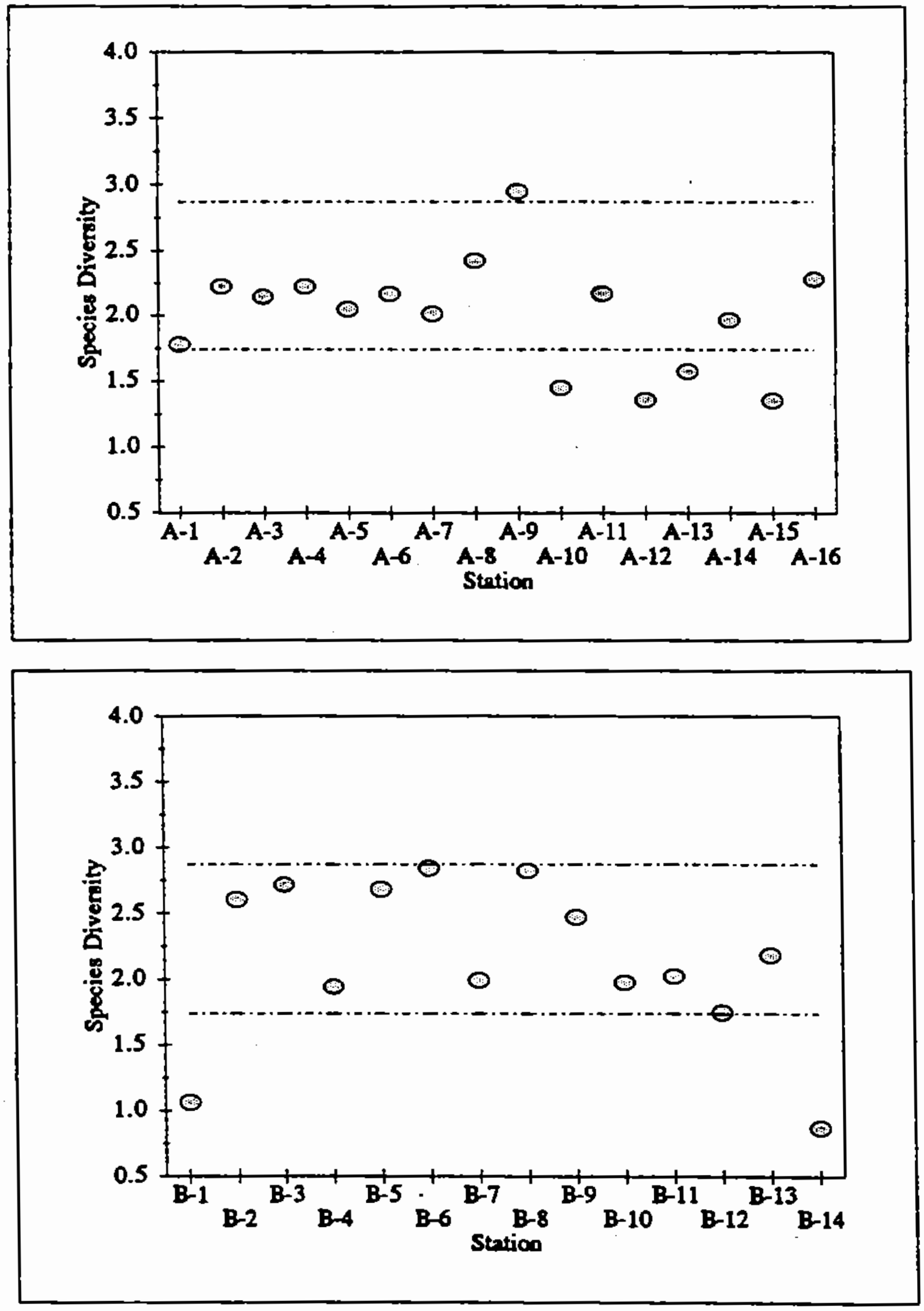

Figure 5. Macrofaunal species diversity at Potential Borrow Area "A" (top) and "B" (bottom) stations in relation to the range of values found at all Reference stations (dashed lines) in the Absecon Inlet study area, 1994.

Table 7. Species diversity (H'), evenness (J'), and Simpson's Index (λ) at stations in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

Station	H'	J'	λ	Station	H'	J'	λ	Station	H'	J'	λ
A-1	1.78	0.59	0.43	B-1	1.06	0.32	0.70	R-1	2.30	0.67	0.27
A-2	2.23	0.79	0.26	B-2	2.61	0.64	0.23	R-2	1.94	0.51	0.41
A-3	2.14	0.68	0.34	B-3	2.72	0.86	0.16	R-3	2.16	0.58	0.35
A-4	2.22	0.70	0.25	B-4	1.94	0.53	0.40	R-4	2.38	0.75	0.23
A-5	2.05	0.88	0.24	B-5	2.68	0.67	0.21	R-5	2.87	0.70	0.20
A-6	2.17	0.63	0.30	B-6	2.84	0.79	0.18	R-6	1.74	0.58	0.44
A-7	2.01	0.78	0.32	B-7	1.99	0.58	0.39	R-7	2.82	0.76	0.20
A-8	2.42	0.94	0.16	B-8	2.82	0.74	0.21	R-8	1.87	0.50	0.37
A-9	2.95	0.93	0.10	B-9	2.47	0.63	0.25				
A-10	1.45	0.38	0.59	B-10	1.98	0.66	0.35				
A-11	2.17	0.72	0.28	B-11	2.03	0.61	0.42				
A-12	1.36	0.58	0.44	B-12	1.75	0.42	0.52				
A-13	1.57	0.45	0.44	B-13	2.18	0.69	0.32				
A-14	1.97	0.85	0.25	B-14	0.87	0.25	0.77				
A-15	1.35	0.68	0.47								
A-16	2.28	0.60	0.25								
Mean	2.01	0.70	0.32		2.14	0.60	0.36		2.26	0.63	0.31
STDS	0.42	0.16	0.13		0.62	0.17	0.19		0.42	0.10	0.10
95% CI	0.21	0.08	0.06		0.32	0.09	0.10		0.29	0.07	0.07

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Station R-7 (Table 7). The mean J' among the Reference stations was 0.63 ($\pm$ 0.07). Simpson's Index (λ) among the Reference stations also varied little, ranging from 0.20 to 0.44 (Table 7). The mean for the area was 0.31 ($\pm$ 0.07).

Selected Taxa—Prior to detailed analyses, the macrofaunal data were examined qualitatively to identify taxa that could be used to characterize the potential borrow areas and Reference stations. Some of these taxa also were useful in characterizing cluster groups resulting from the numerical classification (see *Numerical Classification*). The most striking feature of the macrofaunal community within Potential Borrow Area "A" was the predominance of haustoriid amphipods (Table 8), particularly *Protohaustorius* sp. B (mean abundance = 26.4 $\pm$ 20.53 individuals/0.1 m^2) and *Acanthohaustorius millsi* (mean abundance = 21.2 $\pm$ 10.23 individuals/0.1 m^2). Also noticeable was the relative paucity of polychaete worms, the most common worm being *Magelona papillicornis* (mean abundance = 5.0 $\pm$ 3.08 individuals/0.1 m^2). Capitellid polychaetes occurred at only one station (Station A-13). Four of the five Reference stations associated with Potential Borrow Area "A" (R-1 through R-4) showed similar patterns. The fifth station (Station R-5), located near the inner part of Absecon Inlet, differed substantially from the others. Station R-5 was characterized by relatively high numbers of the polychaete worms *Ophelia denticulata* and *Polydora socialis* and the gastropod *Crepidula fornicata* (Appendix D). *Ophelia denticulata* was uncommon in the remainder of the study area. *Polydora socialis* and *Crepidula fornicata* occurred only at Station R-5.

Although haustoriid amphipods were relatively abundant in Potential Borrow Area "B", the predominant taxon was the small archiannelid worm *Polygordius*, which occurred at a mean density of 70.8 $\pm$ 48.88 individuals/0.1 m^2. *Polygordius* was rare in Potential Borrow Area "A", occurring at only two stations. *Magelona papillicornis* was relatively common in Potential Borrow Area "B" (mean abundance = 9.6 $\pm$ 6.54 individuals/0.1 m^2). Capitellid polychaetes were more common in Potential Borrow Area "B" than in Potential Borrow Area "A", and were particularly common at Station B-6 (Table 8). Generally, these observations held for the Reference stations associated with Potential Borrow Area "B" except that *Polygordius* abundance was low at Station R-8 and haustoriid abundance was low at the Station R-6.

Table 8. Abundance (#/0.1 m^2) of selected taxa in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

Species	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16	Mean	STDS	95% CI
Magelona papillicornis	12	2	3	0	0	15	0	2	0	16	3	0	12	1	0	14	5.0	6.28	3.08
Scolelepis squamata	0	0	0	8	0	3	6	6	0	0	5	0	0	2	0	2	2.0	2.76	1.35
Polygordius	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0.2	0.54	0.27
Capitellidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0.1	0.25	0.12
Acanthohaustorius millsi	14	22	24	22	3	43	22	2	4	6	12	37	55	0	2	71	21.2	20.88	10.23
Protohaustorius sp. B	68	8	1	0	0	55	0	0	0	116	0	0	111	0	0	63	26.4	41.90	20.53
Parahaustorius longimerus	0	7	4	36	10	4	59	4	0	0	31	48	2	6	9	2	13.9	18.77	9.20
Haustoriidae	116	58	33	102	15	120	103	8	5	141	63	101	180	7	15	167	77.1	59.49	29.15
Spisula solidissima	0	1	0	3	6	0	9	2	3	0	1	4	0	0	0	0	1.8	2.64	1.29
Pelecypoda sp. F	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	4.1	14.97	7.33

Species	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10	B-11	B-12	B-13	B-14	Mean	STDS	95% CI
Magelona papillicornis	0	34	1	3	35	1	17	14	16	0	0	14	0	0	9.6	12.49	6.54
Scolelepis squamata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.00	
Polygordius	142	27	9	24	64	0	89	2	19	18	22	262	32	281	70.8	93.32	48.88
Capitellidae	0	12	0	1	0	54	0	1	4	0	0	1	0	0	5.2	14.41	7.55
Acanthohaustorius millsi	0	6	0	0	4	1	2	5	6	0	0	4	0	0	2.0	2.45	1.28
Protohaustorius sp. B	0	87	0	61	26	0	0	41	57	0	1	2	1	1	19.8	29.64	15.53
Parahaustorius longimerus	1	0	3	0	0	0	0	0	0	2	2	4	4	0	1.1	1.56	0.82
Haustoriidae	1	111	3	68	39	1	7	47	70	3	4	27	8	2	27.9	34.57	18.11
Spisula solidissima	3	1	5	4	6	0	1	1	1	1	2	2	0	5	2.3	1.98	1.04
Pelecypoda sp. F	12	85	7	0	31	5	22	16	72	7	2	41	6	3	22.1	26.73	14.00

Species	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	Mean	STDS	95% CI
Magelona papillicornis	7	23	18	13	0	1	21	9	11.5	8.75	6.06
Scolelepis squamata	0	0	0	0	0	0	0	0	0.0	0.00	
Polygordius	0	0	2	0	5	33	38	3	10.1	15.82	10.96
Capitellidae	0	1	0	0	0	13	0	0	1.8	4.56	3.16
Acanthohaustorius millsi	49	30	15	32	0	0	10	5	17.6	17.69	12.26
Protohaustorius sp. B	23	131	98	17	0	0	1	97	45.9	53.66	37.18
Parahaustorius longimerus	5	1	0	4	0	0	2	0	1.5	2.00	1.39
Haustoriidae	87	180	127	81	0	0	19	102	74.5	64.39	44.62
Spisula solidissima	0	0	3	1	2	0	0	0	0.8	1.16	0.81
Pelecypoda sp. F	22	10	27	31	0	0	9	73	21.5	23.86	16.54

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Numerical Classification—The Bray-Curtis similarity analysis showed that all but two stations could be included within two primary dissimilar groups (Figure 6). Excluded from these groups were Stations R-5 and B-6, which were linked to the remaining stations at similarity values of 0.05 and 0.07, respectively. Characteristics of the major groups and the two "outlier" stations are summarized in Table 9. Station R-5 was the inner-most station within Absecon Inlet. Sediments at the station were poorly sorted and had a relatively high gravel component (9.3%). Species diversity here was relatively high ($H' = 2.87$). The fauna characterizing Station R-5 consisted of the gastropod *Crepidula fornicata*, the spionid polychaete *Polydora socialis*, and the opheliid polychaete *Ophelia denticulata*. These species were uncommon (*O. denticulata*) or not found (*C. fornicata, P. socialis*) elsewhere in the study area. Station B-6 was located near the southwest corner of Potential Borrow Area "B" and had the finest sediments of any station in the study area (21.7% silt). Species diversity here was relatively high ($H' = 2.84$). The most noticeable faunistic characteristic of this station was the relatively high abundance (540 individuals/m^2) of capitellid polychaetes.

The first primary station cluster, here termed Group A, was comprised of stations located within Absecon Inlet and linked with the remaining stations at a Bray-Curtis similarity value of 0.10. Sediments at stations within this group were very sandy and varied from very poorly sorted to very well sorted. Infaunal abundance was very low (224 individuals/m^2) and species evenness was high ($J' = 0.9$). Faunal characteristics included very low densities of *Polygordius*, other polychaetes, and haustoriid amphipods.

The remaining 31 stations comprised the second primary station cluster, here termed Group B. Sediments at all stations within this group were sandy and varied from moderately well sorted to very well sorted. Species diversity was relatively low ($H' = 2.0$ to 2.1) and evenness intermediate ($J' = 0.6$). This large group of stations could be separated further into three subgroups, here termed Subgroups B1, B2a, and B2b, that seemed to be distinguished by faunal rather than physical characteristics. Subgroup B1 was comprised of 11 stations located in the central and southeast part of Potential Borrow Area "B" (Figure 6). Included within this subgroup, which joined subgroup B2 at a similarity value of 0.13, were two Reference stations, Stations R-6 and R-7. Faunal characteristics included high densities of *Polygordius* (900 individuals/m^2) and low densities of haustoriid amphipods (100 individuals/m^2).

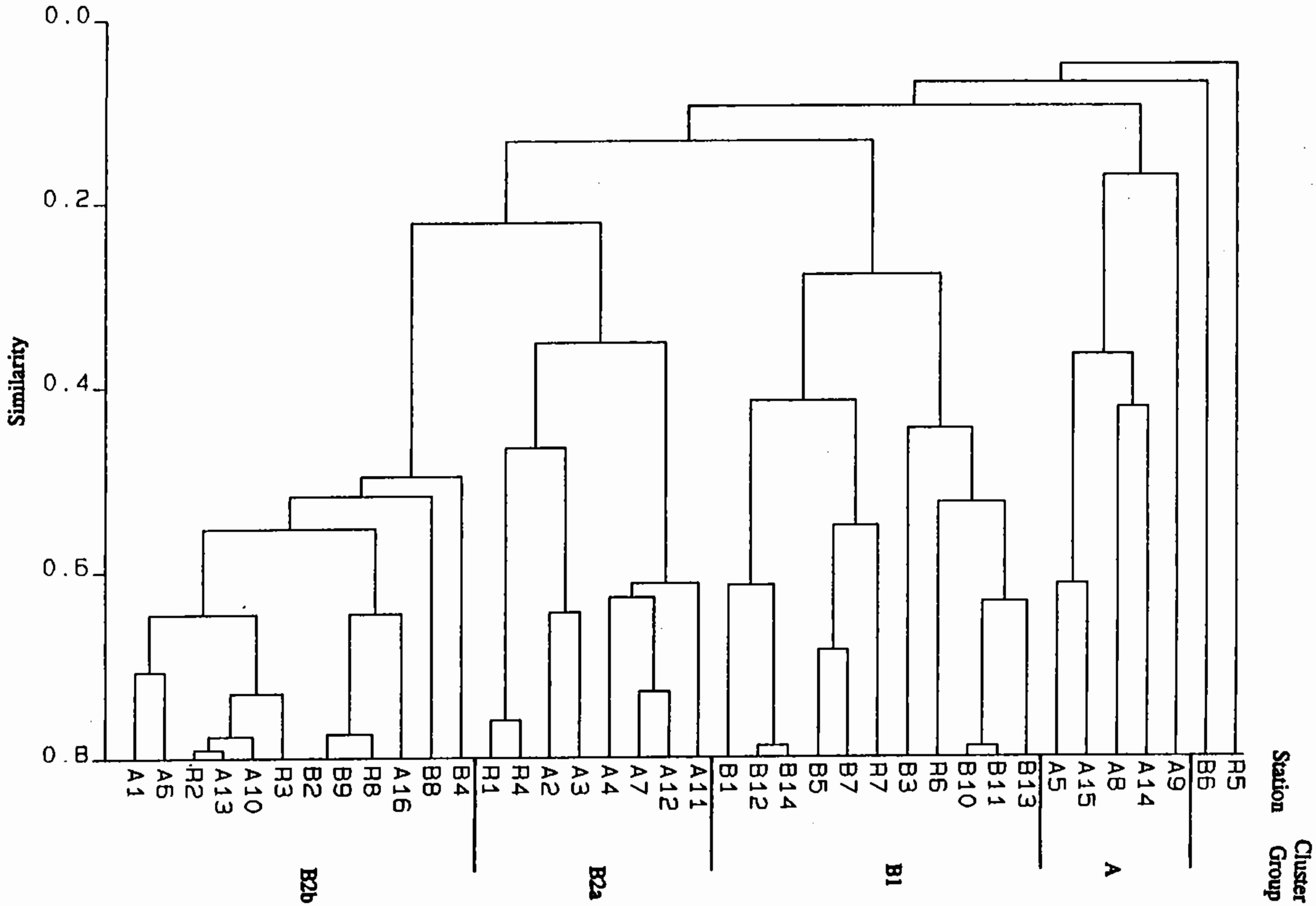

Figure 6. Dendrogram resulting from numerical classification analysis based on Bray-Curtis similarity of stations in the Absecon Inlet study area, 1994.

Table 9. Summary of sedimentary and biological features of cluster groups in the Absecon Inlet study area as defined by Bray-Curtis analyses, 1994.

Cluster Group	Stations/General Location	Sedimentary Features	Biological Features	Faunal Characteristics
—	R-5; Inner part of Absecon Inlet	Sandy (90.6%); poorly sorted; M_z = 1.25	High diversity; high abundance, species	*Ophelia denticulata*, *Polydora socialis*, *Crepidula fornicata*
—	B-6; SW corner PBB[1]	Silty sand (21.7% silt); Moderately sorted; M_z = 3.05	High diversity	High capitellid numbers
A	5; PBA[2], NE fringe of Absecon Inlet, close to shore	Sandy, (95.7%); Very poorly to very well sorted; M_z = 1.61	Low diversity, high evenness; very low abundance	None
B1	11; PBB, SE corner	Sandy; (99.8%); moderately well to very well sorted; M_z = 2.00	Low diversity, moderate evenness, and abundance	High *Polygordius*, low haustoriid amphipods
B2a	8; SW half PBA	Sandy, (99.8%); well to very well sorted; M_z = 2.41	Low diversity moderate evenness and abundance	High *Acanthohaustorius millsi*, *Parahaustorius longimerus*; low *Protohaustorius* sp. B, *Magelona papillicornis*; no *Polygordius*
B2b	12; SE corner PBA, N border PBB	Sandy (99.4%); moderately well to very well sorted; M_z = 2.66	Low diversity, moderate evenness; high abundance	High *Protohaustorius* sp. B, *Magelona papillicornis*; low *Polygordius*; high Pelecypoda sp. F

[1] Potential Borrow Area "B"
[2] Potential Borrow Area "A"

Subgroups B2a and B2b were linked at a similarity value of 0.22 and shared high haustoriid amphipod abundance, but low *Polygordius* densities. Subgroup B2a consisted of eight stations located outside Absecon Inlet along the western part of Potential Borrow Area "A" and included Reference stations R-1 and R-4. Faunal characteristics included relatively high numbers of the haustoriid amphipods *Acanthohaustorius millsi* (280 individuals/m^2) and *Parahaustorius longimerus* (240 individuals/m^2), but low abundances of the haustoriid amphipod *Protohaustorius* sp. B (61 individuals/m^2) and the polychaete *Magelona papillicornis* (40 individuals/m^2). Subgroup B2b consisted of 12 stations located along the eastern offshore portion of Potential Borrow Area "A" and the northern part of Potential Borrow Area "B". Three Reference stations, Stations R-2, R-3, and R-8, were included within this subgroup. Relatively high densities of *Protohaustorius* sp. B (820 individuals/m^2) and *Magelona papillicornis* (160 individuals/m^2) and low numbers of *Parahaustorius longimerus* (10 individuals/m^2) characterized this subgroup. Also characteristic of subgroup B2b was relatively high densities of a small bivalve mollusc tentatively identified as Pelecypoda fam. F. This small clam may be a juvenile *Spisula solidissima*. Mean density of Pelecypoda fam. F among stations comprising subgroup B2b was 298 ($\pm$ 189) individuals/m^2, although densities exceeded 600 individuals/m^2 at four stations.

It is interesting that the grouping of stations based on biological similarity reflected a subtle sedimentological transition from medium to fine sand (Figure 7). Group A sediments, though variable, were generally medium sand (mean $M_z = 1.61 \pm 0.87$), whereas Subgroup B1 sediments were fine sand ($M_z = 2.00 \pm 0.36$). Subgroup B2 sediments ($M_z = 2.56 \pm 0.22$) were also fine sand, but graded more toward very fine sand. However, this gradation did not represent a transition from nearshore towards offshore stations as Subgroup B1 stations were located seaward of Subgroup B2 stations (Figure 7).

Wet-Weight Biomass—Total wet-weight biomass varied considerably throughout the study area (Figure 8, Table 10). Much of this variation was attributable to the contribution made by larger individuals of *Spisula solidissima* and the brachyuran crabs *Cancer irroratus* and *Ovalipes ocellatus* at some stations. Although these individuals were not weighed separately, their contribution to total biomass at each station could be inferred by comparing the data for taxa measuring $\geq$ 2 cm (see *Infaunal Size Fractions and Empty Commercial Bivalves*) with the biomass data. This exercise showed that samples from all stations in Potential Borrow Area "A", except Station A-1, for which biomass exceeded 2 g/0.1 m^2 contained larger individuals of

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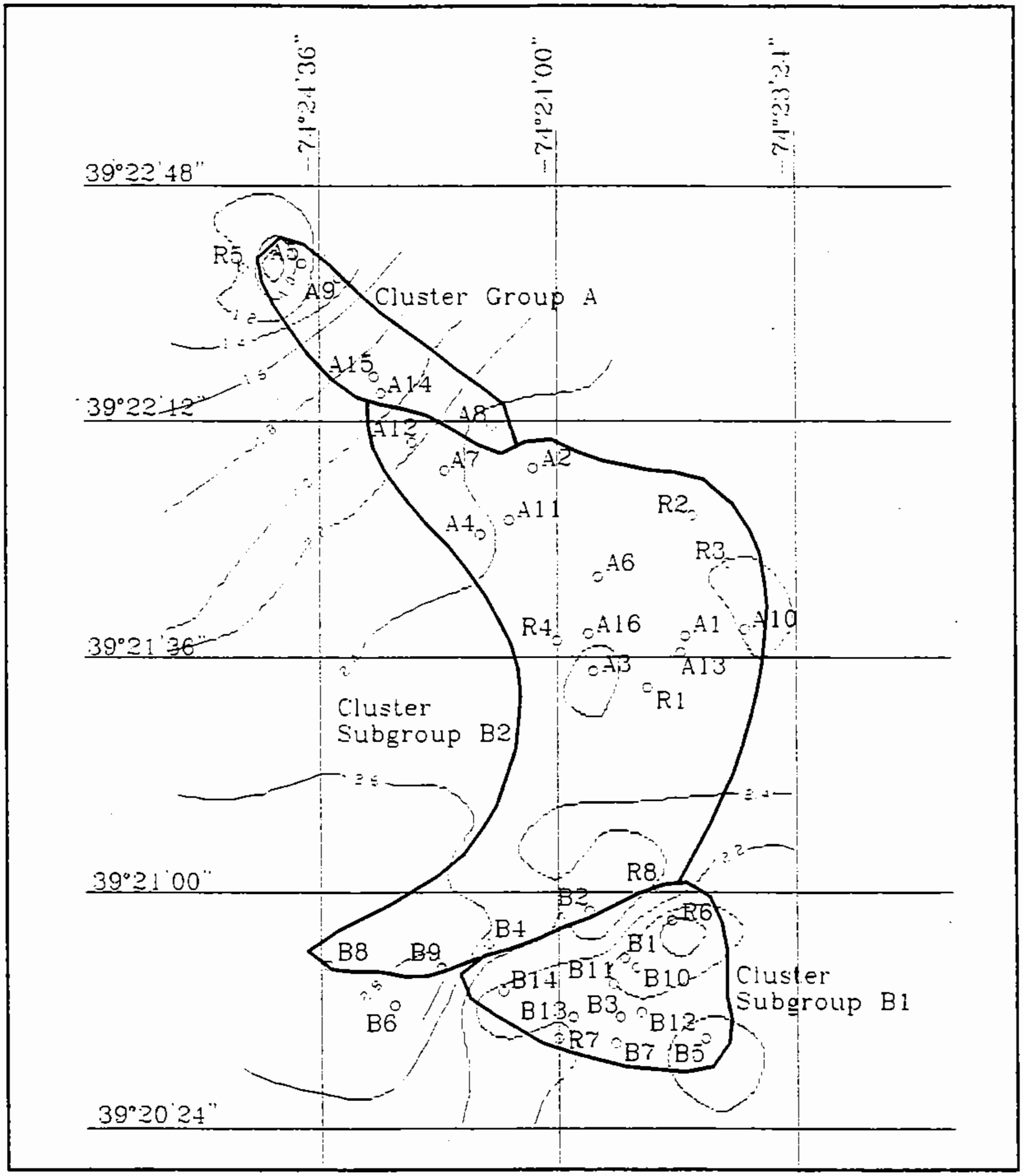

Figure 7. Contour plot of graphic mean phi (M_z) in the Absecon Inlet study area, 1994 with stations comprising the three main cluster groups circled.

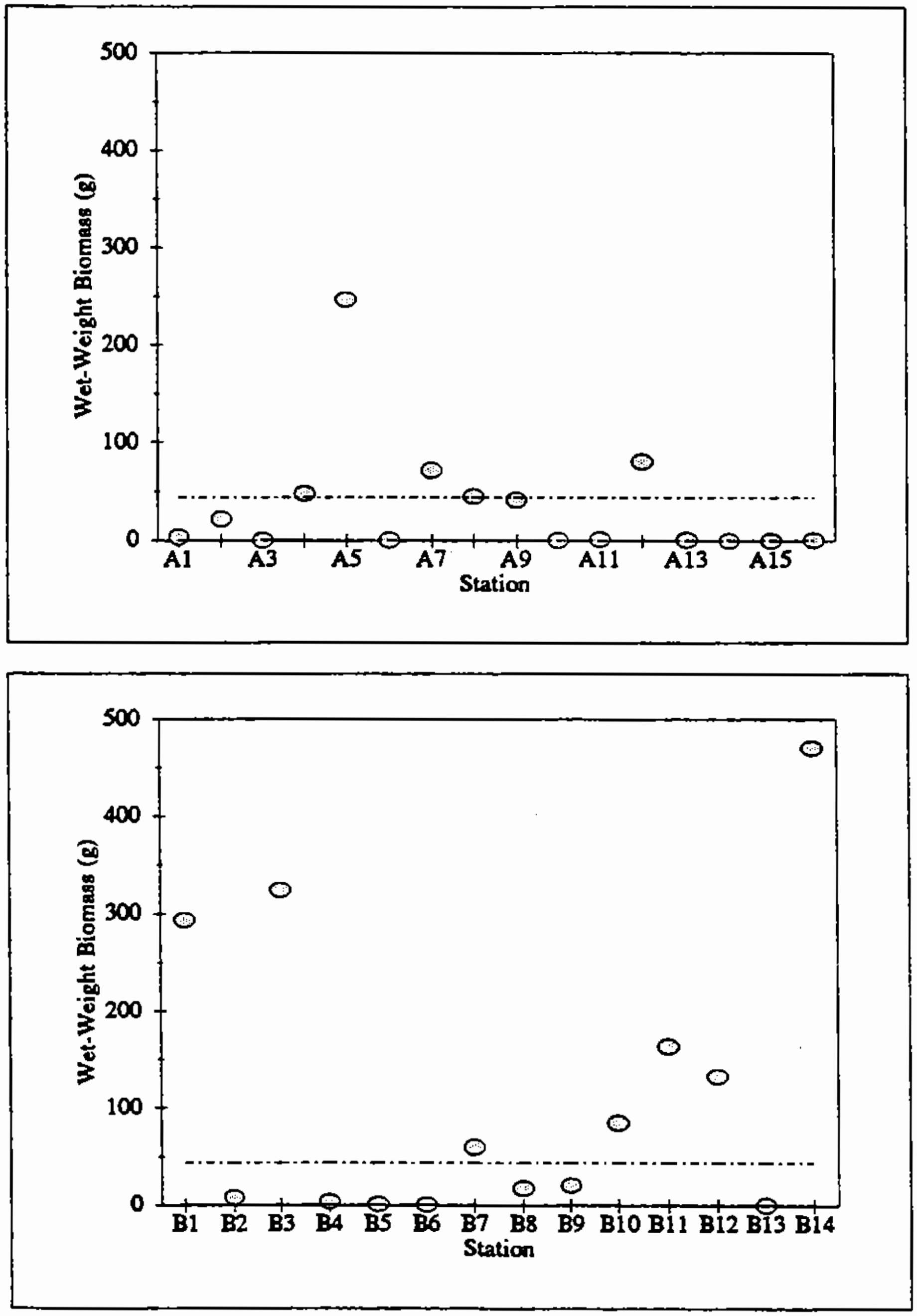

Figure 8. Wet-weight biomass (g/0.1 m^2) at Potential Borrow Area "A" (top) and "B" (bottom) stations in relation to the range of values found at all reference stations (dashed lines) in the Absecon Inlet study area, 1994. Note: The lowest value found among the reference stations was 0.176 g/0.1 m^2.

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Table 10. Wet-weight biomass (g/0.1 m^2) and percent contribution of major taxonomic groups in the Absecon Inlet study area, 1994. Mean, standard deviation (STDS), and 95% confidence intervals (CI) are provided.

	Wet-Weight Biomass					Percent Contribution		
Station	Annelida	Arthropoda	Mollusca	Misc.	Total	Annelida	Arthropoda	Mollusca
A1	0.061	0.053	3.323	0.008	3.445	1.77%	1.54%	96.46%
A2	0.001	0.103	21.592	0.001	21.697	0.00%	0.47%	99.52%
A3	0.026	0.399	0.000	0.001	0.426	6.10%	93.66%	0.00%
A4	0.022	3.523	44.427	0	47.972	0.05%	7.34%	92.61%
A5	0.001	0.169	246.500	0	246.67	0.00%	0.07%	99.93%
A6	0.051	0.174	0.010	0.008	0.243	20.99%	71.60%	4.12%
A7	0.003	0.339	71.000	0	71.342	0.00%	0.48%	99.52%
A8	0.122	0.017	45.000	0	45.139	0.27%	0.04%	99.69%
A9	0.006	0.013	41.500	0.04	41.559	0.01%	0.03%	99.86%
A10	0.132	0.322	0.000	0.001	0.455	29.01%	70.77%	0.00%
A11	0.006	0.081	1.282	0.004	1.373	0.44%	5.90%	93.37%
A12	0.001	20.700	60.000	0	80.701	0.00%	25.65%	74.35%
A13	0.007	0.596	0.366	0.016	0.985	0.71%	60.51%	37.16%
A14	0.003	0.036	0.000	0.001	0.04	7.50%	90.00%	0.00%
A15	0.000	0.008	0.000	0.001	0.009	0.00%	88.89%	0.00%
A16	0.060	0.460	0.008	0.007	0.535	11.21%	85.98%	1.50%
Mean	0.031	1.687	33.438	0.006	35.162			
STDS	0.043	5.141	62.029	0.010	62.832			
95% CI	0.021	2.519	30.394	0.005	30.787			
B1	0.399	0.107	293.053	0.001	293.56	0.14%	0.04%	99.83%
B2	0.115	0.045	8.275	0.007	8.442	1.36%	0.53%	98.02%
B3	0.017	0.466	324.355	0	324.838	0.01%	0.14%	99.85%
B4	0.040	0.180	3.797	0.001	4.018	1.00%	4.48%	94.50%
B5	0.047	0.054	0.350	0.807	1.258	3.74%	4.29%	27.82%
B6	0.460	0.002	0.146	0.001	0.609	75.53%	0.33%	23.97%
B7	0.017	0.159	60.100	0	60.276	0.03%	0.26%	99.71%
B8	0.014	0.033	17.808	0.004	17.859	0.08%	0.18%	99.71%
B9	0.031	0.037	20.658	0.031	20.757	0.15%	0.18%	99.52%
B10	0.012	0.034	85.010	0.001	85.057	0.01%	0.04%	99.94%
B11	0.059	0.057	164.000	0.002	164.118	0.04%	0.03%	99.93%
B12	0.161	1.200	131.000	0.002	132.363	0.12%	0.91%	98.97%
B13	0.154	0.116	0.030	0.032	0.332	46.39%	34.94%	9.04%
B14	0.179	0.137	470.000	0	470.316	0.04%	0.03%	99.93%
Mean	0.122	0.188	112.756	0.064	113.129			
STDS	0.143	0.313	149.284	0.214	149.327			
95% CI	0.075	0.164	78.198	0.112	78.221			
R1	0.020	0.150	0.001	0.005	0.176	11.36%	85.23%	0.57%
R2	0.101	0.073	1.030	0.005	1.209	8.35%	6.04%	85.19%
R3	0.125	0.053	6.643	0	6.821	1.83%	0.78%	97.39%
R4	0.011	0.624	28.055	0.001	28.691	0.04%	2.17%	97.78%
R5	0.073	1.500	42.340	0.001	43.914	0.17%	3.42%	96.42%
R6	0.284	0.044	0.014	0.001	0.343	82.80%	12.83%	4.08%
R7	0.135	0.154	1.246	0.001	1.536	8.79%	10.03%	81.12%
R8	0.050	0.037	0.105	0	0.192	26.04%	19.27%	54.69%
Mean	0.100	0.329	9.929	0.002	10.360			
STDS	0.087	0.511	16.203	0.002	16.662			
95% CI	0.060	0.354	11.228	0.001	11.546			

the three species. *Mercenaria mercenaria* probably contributed substantially to total biomass (3.445 g) at Station A-1.

Similarly, samples from all stations in Potential Borrow Area "B", except Station B-4, having a total wet-weight biomass that exceeded 2 g/0.1 m^2 contained large individuals of one or more of the three species named above. Small specimens of *Spisula* and one individual of the gastropod *Ilyanassa trivittata* comprised a substantial part (3.797 g) of the total biomass (4.018 g) at Station B-4.

Among the Reference stations, total wet-weight biomass was much lower than at either potential borrow area (Table 10). The numbers of larger *Spisula* or brachyuran crabs at the Reference stations was much lower than at the potential borrow areas.

Correlation with Physical Factors—Pearson correlation coefficients were calculated between certain biological parameters and station depth, station DO, sediment percent sand, sediment numerical mean phi, and sediment graphic mean phi (Table 11). No significant correlations were found between DO and any biological parameter. However, this result is not surprising because waters throughout the study area were well-oxygenated and all DO levels were above potentially harmful levels. Annelid abundance, the number of annelid species, and the abundance of capitellid polychaetes were positively correlated with station depth. The abundance and number of species of arthropods and molluscs were positively correlated with sediment numerical mean phi. Species diversity (H') and capitellid polychaete abundance were negatively correlated with sediment percent sand. The correlation, or lack thereof, between capitellids and abiotic factors should be viewed with caution because the group was found at high abundance at one station, but at low abundance at the other stations. These relationships could be driven by the single high abundance station, Station B-6. Four of the selected taxa were positively correlated with sediment numerical mean phi (Table 11). Because detectable TOC levels were found at only six stations, no correlation analysis between TOC and the biological measures was attempted.

Table 11. Pearson correlation coefficients (r) between selected biological and sedimentary parameters in the Absecon Inlet study area, 1994. Critical limits are from Rohlf and Sokal (1969); significant correlations are shaded.

Biological Parameter		% Sand	Sedimentary Parameter Graphic Mean	Numerical Mean	Depth (m)	DO (mg/L)
Indices	*H'*	-0.408	0.072	0.259	0.032	0.063
	J'	-0.295	-0.152	-0.056	-0.276	0.300
	λ	0.316	-0.054	-0.182	0.156	-0.171
Abundance	Total	0.116	0.375	0.377	0.271	-0.269
	Annelids	-0.060	-0.058	-0.019	0.432	-0.218
	Arthropods	0.247	0.534	0.475	-0.227	-0.070
	Molluscs	0.050	0.348	0.381	0.297	-0.226
Species	Total	0.180	0.306	0.283	0.248	-0.267
	Annelids	0.012	-0.109	-0.101	0.387	-0.216
	Arthropods	0.244	0.527	0.471	-0.218	-0.074
	Molluscs	0.116	0.335	0.346	0.244	-0.197
Selected Taxa	*Polygordius*	0.126	-0.156	-0.186	0.241	-0.229
	Magelona papillicornis	0.196	0.465	0.424	0.006	-0.296
	Scolelepis squamata	0.126	0.104	0.020	-0.144	0.069
	Capitellidae	-0.742	0.231	0.499	0.337	0.118
	Protohaustorius sp. B	0.149	0.489	0.483	-0.147	-0.195
	Acanthohaustorius millsi	0.185	0.312	0.245	-0.321	0.155
	Parahaustorius longimerus	0.146	0.018	-0.060	-0.027	0.140
	Haustoriids	0.250	0.531	0.469	-0.252	-0.058
	Spisula solidissima	0.076	-0.198	-0.171	0.084	0.035
	Spisula + *F*	0.158	0.391	0.396	0.125	-0.246
	% Sand				-0.229	

Critical Limits (n = 38) =
0.3208 ($\alpha = 0.05$) 0.413 ($\alpha = 0.01$)

Infaunal Size Fractions and Empty Commercial Bivalves—Sixteen species were found to be ≥ 2 cm in length (Table 12). Of these, ten species were polychaete annelids. The most frequently occurring species ≥ 2 cm in length were the bivalve *Spisula solidissima* (21 stations) and the polychaete worm *Nephtys bucera* (4 stations). The mean abundance of infaunal organisms ≥ 2 cm in length was very low, with fewer than two individuals per station being found at either potential borrow area or among the Reference stations.

Empty shells of three species of commercially important bivalves were found in the study area (Table 13). *Spisula solidissima* (Atlantic surf clam) was the most numerous species and occurred at more stations than the others. *Mytilus edulis* (blue mussel) was the next most frequently occurring species. *Argopecten irradians* (bay scallop) was the third species of commercial importance found. Only five living individuals of *Mytilus edulis*, but no living specimens of *Argopecten irradians* were collected during the grab-sampling activities. One small individual (< 2-cm length) of *Mercenaria mercenaria* (northern quahog) was found among the grab samples, but no empty *Mercenaria* shells were found.

SUMMARY AND CONCLUSIONS

Water Quality—The measured water-quality parameters varied little across the study area. All values were similar to those reported for other coastal areas to the north (New York Bight) or south (mouth of Delaware Bay). For example, salinity in the study area (~31.5 ‰) was only slightly higher than that (30.7 ‰) found of Hen and Chicken Shoals, Delaware in October (Maurer *et al.*, 1979) and about the same as values (31-32 ‰) found off northern New Jersey (Mountain, 1991). Waters throughout the study area were well-oxygenated; DO levels were slightly higher than those reported for the New York Bight apex, which is known to have somewhat low DO levels (Draxler *et al.*, 1991).

Sediments—With the exception of Station B-6, sediments within the study area ranged from very coarse sand to very fine sand. Sands within Absecon inlet tended to be slightly coarser than those offshore. However, sands at stations located furthest offshore were slightly finer (very fine sand) than those at stations in the middle of the study area (fine sand).

Table 12. Macrofaunal species in the Absecon Inlet study area having lengths ≥ 2 cm, 1994. Occurrence and the mean and standard deviation (STDS) number of individuals per station are provided.

	Area A			Area B			Reference Sites		
Species	# Sta.	Mean	STDS	# Stations	Mean	STDS	# Stations	Mean	STDS
Annelida									
Ampharete sp. C	0			1	0.1	0.27	0		
Caulleriella sp. J	1	0.1	0.25	0			0		
Dispio uncinata	0			0			1	0.13	0.35
Glycera dibranchiata	0			0			2	0.25	0.46
Leitoscoloplos fragilis	0			1	0.1	0.27	0		
Magelona papillicornis	1	0.1	0.50	0			0		
Nephtys bucera	3	0.3	0.70	1	0.1	0.27	0		
Nephtys picta	0			1	0.1	0.27	0		
Phyllodoce arenae	0			1	0.1	0.27	0		
Sigalion arenicola	0			1	0.1	0.27	0		
Mollusca									
Ilyanassa trivittata	0			1	0.1	0.27	1	0.13	0.35
Spisula solidissima	7	1.7	2.65	11	1.9	2.02	3	0.50	0.76
Arthropoda									
Cancer irroratus	1	0.1	0.25	0			1	0.13	0.35
Ovalipes ocellatus	1	0.1	0.25	1			0		
Pagurus longicarpus	1	0.1	0.25	0			0		
Pagurus politus	1	0.1	0.25	1	0.1	0.27	0		

Table 13. Occurrence, mean and standard deviation (STDS) number of individuals per station, and size range of empty commercial bivalves in the Absecon Inlet study area, 1994.

	Area A		
Species	# Stations	Mean	STDS
Argopecten irradians	4	0.9	1.84
Mytilus edulis	8	9.4	19.12
Spisula solidissima	11	34.9	58.14

	Area B		
Species	# Stations	Mean	STDS
Argopecten irradians	0	0.0	0.00
Mytilus edulis	3	0.2	0.43
Spisula solidissima	10	9.7	11.27

	Reference Sites		
Species	# Stations	Mean	STDS
Argopecten irradians	1	0.8	2.12
Mytilus edulis	2	0.9	2.10
Spisula solidissima	7	10.6	14.42

Macrofaunal Communities—Methodological differences between the present study and some published studies make direct comparisons of results inappropriate. For example, although Maurer *et al.* (1979) used the same size grab as was used in this study (0.1 m^2), their samples were rinsed over a 1.0-mm sieve rather than a 0.5-mm sieve. However, general comparisons are useful. Total infaunal abundance found during the Brigantine Inlet Feasibility study may be roughly comparable to that found for an offshore sandy area near Delaware Bay. The abundance values for offshore stations reported here (~1400 to 1600 individuals/m^2) are higher than those reported by Maurer *et al.* (1979) for Hen and Chicken Shoals samples also collected in the fall (October 1973). They reported abundances ranging from about 100 to 700 individuals/m^2 for stations located a depths similar to those occurring in the Absecon Inlet area. As mentioned above, samples studied by Maurer *et al.* (1979) were rinsed over a 1.0-mm mesh sieve, thus abundances would be expected to be lower. The relative importance of haustoriid amphipods in the sandy macrofaunal communities off Absecon Inlet mirrors that found by Maurer *et al.* (1979). Maurer *et al.* (1979) also noted that species of haustoriids generally differed in their distribution relative to shore. *Acanthohaustorius millsi* typically occurred nearshore, whereas *Parahaustorius longimerus* occurred farther offshore. At Absecon Inlet, both species characterized relatively nearshore stations, whereas *Protohaustorius* sp. B characterized offshore stations.

Live surf clams, *Spisula solidissima*, were scattered throughout the offshore portions of the study area, reaching a maximum density of about 90 individuals/m^2 Station A-7. Pearce *et al.* (1981) summarized the biology of *Spisula* and reported dense surf clam beds off Pt. Pleasant and Cape May, NJ, although clam densities in those areas were not specified. Caracciolo and Steimle (1983) reported surf clam densities of about 20-70 individuals/m^2 off northern New Jersey. Both studies summarized information on reproduction and growth of surf clams, pointing out that surf clams may have two annual spawning periods, one in late summer and one in late fall and mention that larvae may reach settlement size within 19 days (at 22° C). High numbers of small clams occurred in portions of the study area, especially among stations comprising Bray-Curtis cluster group B2b. If these clams, which were tentatively identified as Pelecypoda fam. F, are juvenile *Spisula,* their presence within the study area may have resulted from late summer spawning activities, followed by relatively slow development in cool (~15° C) waters. This may indicate that those areas are important settlement sites in the fall.

Only one station (Station B-6) had high numbers of capitellid polychaetes that typically occur in disturbed areas (Grassle and Grassle, 1974). The fauna at other offshore stations appeared to be typical for nearshore sandy habitats. Commercial species, other than *Spisula*, were not common in the study area.

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APPENDIX A
TIDE CHART

The Press
OF ATLANTIC CITY

1994 TIDE TABLES FOR ATLANTIC OCEAN

Tides in these Tables are Figured For Atlantic City

	High Water Hrs./Mins. Add	Low Water Hrs./Mins. Add
Absecon Creek Entrance	1:30	1:54
Absecon Inlet (Gardner's Basin)	:40	:36
Barnegate Inlet	:06	:16
Beach Thorofare (Shelter Island)	1:05	1:09
Brigantine Channel	:27	:40
Broad Creek (Middle Thorofare)	1:21	1:10
Cape May Municipal Pier	:28	:20
Corson Inlte (Bridge)	:35	:41
Chestnut Neck, Mullica River	1:50	2:32
Great Egg Harbor Inlet	:38	:32
Grassy Bay	1:34	1:48
Graveling Point	1:05	1:46

	High Water Hrs./Mins. Add	Low Water Hrs./Mins. Add
Hereford Inlet (North Wildwood)	:28	:39
Little Egg Inlet	:25	:34
Longport (Inside)	:31	:36
Manasquan Inlet	:14	:01
Mays Landing	2:52	3:13
Ocean City (9th St. Bridge)	:50	:56
Scull Landing	2:09	2:31
Sea Isle City (Beach)	:07	:18
Sea Isle City (Ludlam Thoro. Bridge)	1:11	1:26
Stone Harbor (Great Channel Bridge)	1:08	1:03
Townsend Inlet	:32	:41
West Wildwood (Grassy Sound Bridge)	1:11	1:06
Wildwood (Beach)	:11	:18

Tides Figured by Capt. Glenn A. Westervelt

THE PRESS TIDE TABLES FOR 1994

Times shown are Daylight Savings Time from Sun., April 3 to Sun., Oct. 30
N-New Moon; 1/4-1st Quarter; F-Full Moon; 3/4-3rd Quarter

JULY

Day/Date	Moon Phase	HIGH AM	HIGH PM	LOW AM	LOW PM
1 FRI.		1:52	2:38	8:07	8:54
2 SAT.		2:44	3:19	8:59	9:48
3 SUN.		3:40	4:14	9:49	10:39
•4 MON.	INDEPENDENCE DAY	4:39	5:06	10:36	11:28
5 TUES.		5:34	5:55	11:23	—
6 WED.		6:23	6:39	00:16	12:20
7 THURS.		7:18	7:20	1:03	12:57
8 FRI.	N	7:50	7:59	1:48	1:43
9 SAT.		8:31	8:48	2:40	2:27
10 SUN.		9:12	9:28	3:20	3:19
11 MON.		9:55	10:01	3:49	3:52
12 TUES.		10:41	10:47	4:27	4:35
13 WED.		11:30	11:37	5:07	5:24
14 THURS.		—	12:22	5:51	6:21
15 FRI.		00:30	1:16	6:44	11:26
16 SAT.	1/4	1:38	2:15	7:46	8:37
17 SUN.		2:31	3:17	8:51	9:43
18 MON.		3:40	4:22	9:53	10:43
19 TUE.		4:50	5:25	10:52	11:41
20 WED.		5:53	6:21	—	12:01
21 THURS.		6:49	7:12	00:36	12:46
22 FRI.	F	7:39	7:59	1:29	1:50
23 SAT.		8:26	8:44	2:18	2:31
24 SUN.		9:12	9:38	3:03	3:18
25 MON.		9:56	10:12	3:45	4:02
26 TUE.		10:41	10:56	4:25	4:45
27 WED.		11:25	11:39	5:04	5:28
28 THUR.		—	12:09	5:44	6:15
29 FRI.		00:23	12:541	6:27	7:08
30 SAT.	3/4	1:09	1:40	7:15	8:07
31 SUN.		1:58	2:30	8:20	9:07

AUGUST

Day/Date	Moon Phase	HIGH AM	HIGH PM	LOW AM	LOW PM
1 MON.		2:54	3:26	9:06	10:02
2 TUES.		3:56	4:24	9:59	10:54
3 WED.		5:08	5:20	11:00	11:43
4 THURS.		5:52	6:09	11:50	—
5 FRI.		6:40	6:54	00:31	12:39
6 SAT.		7:24	7:36	1:17	1:18
7 SUN.	N	8:05	8:17	2:10	2:05
8 MON.		8:57	8:58	2:42	3:00
9 TUES.		9:31	9:42	3:22	3:35
10 WED.		10:17	10:29	4:02	4:21
11 THURS.		11:07	11:20	4:44	5:20
12 FRI.		—	12:01	5:29	6:06
13 SAT.		00:15	12:56	6:22	7:11
14 SUN.	1/4	1:14	1:56	7:26	8:21
15 MON.		2:28	3:00	8:35	9:28
16 TUES.		3:38	4:06	9:41	10:29
17 WED.		4:39	5:10	10:42	11:26
18 THURS.		5:42	6:07	11:39	—
19 FRI.		6:36	6:56	00:19	12:33
20 SAT.		7:22	7:41	1:08	1:24
21 SUN.	F	8:05	8:22	1:54	2:12
22 MON.		8:46	9:03	2:36	2:56
23 TUES.		9:25	9:42	3:16	3:37
24 WED.		10:05	10:21	3:52	4:16
25 THURS.		10:44	11:01	4:25	4:54
26 FRI.		11:25	11:43	5:02	5:35
27 SAT.		—	12:07	5:39	6:21
28 SUN.		00:27	12:52	6:11	7:18
29 MON.	3/4	1:16	1:41	7:15	8:22
30 TUES.		2:12	2:37	8:30	9:23
31 WED.		3:15	3:40	9:23	10:15

SEPTEMBER

Day/Date	Moon Phase	HIGH AM	HIGH PM	LOW AM	LOW PM
1 THURS.		4:20	4:41	10:19	11:08
2 FRI.		5:19	5:47	11:12	11:55
3 SAT.		6:10	6:25	—	12:03
4 SUN.		6:55	7:09	00:42	12:53
5 MON.	LABOR DAY	7:39	7:53	1:27	1:42
6 TUES.		8:22	8:37	2:11	2:40
7 WED.		9:06	9:22	2:54	3:18
8 THURS.		9:54	10:11	3:37	4:03
9 FRI.		10:45	11:04	4:21	4:56
10 SAT.		11:40	—	5:19	5:31
11 SUN.		00:02	12:38	6:04	6:55
12 MON.	1/4	1:03	1:48	7:10	8:04
13 TUES.		2:18	2:43	8:22	9:12
14 WED.		3:17	3:49	9:30	10:12
15 THURS.		4:26	4:53	10:40	11:06
16 FRI.		5:37	5:49	11:26	11:56
17 SAT.		6:18	6:47	—	12:17
18 SUN.		7:02	7:19	00:42	1:06
19 MON.	F	7:41	8:08	1:25	2:00
20 TUES.		8:28	8:36	2:06	2:32
21 WED.		8:54	9:12	2:46	3:11
22 THURS.		9:30	9:49	3:19	3:49
23 FRI.		10:06	10:37	3:53	4:25
24 SAT.		10:43	11:07	4:25	5:01
25 SUN.		11:23	11:51	4:57	5:42
26 MON.		—	12:07	5:33	6:32
27 TUES.		00:40	12:56	6:22	7:34
28 WED.	3/4	1:35	1:52	7:32	8:41
29 THURS.		2:37	2:55	8:45	9:39
30 FRI.	F	3:42	4:00	9:45	10:30

APPENDIX B
WATER-QUALITY DATA

Brigantine Inlet OCTOBER 20 1994 Station A-1

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
37694.29	39.36100	-74.39367	0.28	15.675	31.550	8.06	6.84
37696.79	39.36083	-74.39384	0.28	15.675	31.557	8.06	6.88
37697.29			0.34	15.688	31.546	8.04	6.89
37697.79			0.45	15.680	31.548	8.04	6.90
37698.29			0.53	15.682	31.548	8.04	6.88
37698.79	39.36083	-74.39367	0.56	15.675	31.560	8.04	6.90
37699.29			0.40	15.672	31.560	8.04	6.92
37699.79			0.42	15.685	31.548	8.04	6.89
37700.29			0.70	15.677	31.558	8.03	6.86
37700.79	39.36083	-74.39367	0.97	15.669	31.561	8.03	6.87
37701.29			1.29	15.669	31.554	8.03	6.88
37701.79			1.59	15.693	31.545	8.03	6.90
37702.29			1.74	15.667	31.562	8.03	6.94
37702.79	39.36083	-74.39367	1.91	15.661	31.561	8.03	6.99
37703.29			2.18	15.667	31.559	8.03	7.02
37703.79			2.42	15.666	31.566	8.03	7.03
37704.29			2.63	15.669	31.557	8.03	7.03
37704.79	39.36083	-74.39367	2.85	15.669	31.553	8.03	7.02
37705.29			3.05	15.671	31.555	8.03	7.02
37705.79			3.16	15.659	31.565	8.03	7.04
37706.29			3.19	15.677	31.554	8.03	7.05
37706.79	39.36083	-74.39367	3.26	15.664	31.567	8.04	7.07
37707.29			3.47	15.661	31.566	8.03	7.06
37707.79			3.61	15.666	31.559	8.03	7.04
37708.29			3.70	15.677	31.557	8.03	7.01
37708.79	39.36067	-74.39367	3.75	15.683	31.545	8.03	6.99
37709.29			3.90	15.669	31.563	8.03	6.97
37709.79			4.07	15.669	31.556	8.03	6.97
37710.29			4.31	15.664	31.567	8.03	6.97
37710.79	39.36067	-74.39384	4.45	15.672	31.564	8.03	6.95
37711.29			4.49	15.666	31.566	8.03	6.91
37711.79			4.58	15.683	31.552	8.03	6.86
37712.29			4.81	15.671	31.558	8.03	6.83
37712.79	39.36067	-74.39384	5.02	15.685	31.558	8.03	6.85
37713.29			5.13	15.677	31.564	8.03	6.89
37713.79			5.17	15.688	31.551	8.03	6.86
37714.29			5.24	15.670	31.566	8.03	6.83
37714.79	39.36067	-74.39384	5.38	15.680	31.554	8.03	6.82
37715.29			5.54	15.661	31.573	8.03	6.83
37715.79			5.64	15.675	31.569	8.03	6.82
37752.91	39.36083	-74.39367	5.78	15.696	31.544	8.03	6.81

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Brigantine Inlet OCTOBER 21 1994 Station A-2

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
29820.80	39.36767	-74.40100	0.19	15.610	31.477	8.12	6.98
29826.95			0.21	15.604	31.482	8.12	6.98
29827.69			0.23	15.610	31.473	8.12	6.96
29828.43	39.36767	-74.40100	0.37	15.601	31.480	8.12	6.94
29828.92			0.57	15.591	31.482	8.12	6.93
29829.42			0.78	15.596	31.481	8.12	6.94
29829.91			0.90	15.604	31.482	8.12	6.94
29830.40	39.36767	-74.40100	1.05	15.591	31.491	8.11	6.94
29830.89			1.24	15.599	31.485	8.12	6.92
29831.38			1.33	15.593	31.490	8.12	6.91
29831.88			1.44	15.599	31.489	8.12	6.92
29832.37	39.36767	-74.40100	1.59	15.599	31.492	8.12	6.94
29832.86			1.72	15.594	31.493	8.12	6.96
29833.35			1.82	15.601	31.483	8.11	6.97
29833.85			2.00	15.598	31.486	8.11	6.97
29834.34	39.36767	-74.40100	2.20	15.604	31.485	8.12	6.96
29834.83			2.37	15.604	31.481	8.11	6.96
29835.32			2.54	15.607	31.482	8.11	6.96
29835.81			2.73	15.591	31.488	8.11	6.92
29836.31	39.36767	-74.40100	2.84	15.601	31.486	8.10	6.90
29836.80			2.96	15.596	31.488	8.10	6.87
29837.29			3.26	15.607	31.482	8.11	6.85
29837.78			3.46	15.594	31.492	8.13	6.86
29838.28	39.36767	-74.40100	3.61	15.607	31.482	8.16	6.87
29838.77			3.77	15.607	31.481	8.17	6.86
29839.26			3.91	15.615	31.475	8.18	6.86
29839.75			3.93	15.607	31.478	8.18	6.88
29855.63	39.36767	-74.40100					

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Brigantine Inlet OCTOBER 20 1994 Station A-3

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
27061.94	39.35933	-74.39833	0.10	15.586	31.562	8.08	6.85
27067.86	39.35933	-74.39833	0.26	15.578	31.567	8.08	6.90
27068.61			0.76	15.578	31.559	8.08	6.93
27069.36	39.35933	-74.39833	1.15	15.567	31.573	8.07	6.91
27070.11			1.34	15.583	31.562	8.07	6.92
27070.86			1.71	15.576	31.566	8.07	6.97
27071.61	39.35933	-74.39833	1.89	15.583	31.557	8.07	7.01
27072.36			2.16	15.584	31.561	8.07	7.05
27073.11	39.35933	-74.39833	2.54	15.585	31.560	8.07	7.05
27073.86			2.68	15.571	31.575	8.07	7.09
270-74.61			2.87	15.578	31.563	8.07	7.04
27075.36	39.35933	-74.39833	3.19	15.581	31.561	8.07	7.00
27076.11			3.47	15.573	31.568	8.06	7.03
27076.86			3.69	15.566	31.574	8.07	6.97
27077.61	39.35933	-74.39833	3.90	15.578	31.563	8.07	6.83
27078.36			3.99	15.569	31.570	8.06	6.75
27079.11	39.35933	-74.39833	4.23	15.567	31.572	8.06	6.75
27079.86			4.60	15.576	31.565	8.07	6.74
27080.61			4.72	15.571	31.561	8.07	6.71
27081.36	39.35933	-74.39833	5.01	15.566	31.566	8.07	6.60
27082.11			5.13	15.574	31.562	8.07	6.51
27082.86			5.09	15.573	31.565	8.07	6.54
27083.61	39.35933	-74.39833	5.27	15.574	31.564	8.07	6.65
27084.36			5.48	15.580	31.560	8.06	6.71
27085.11	39.35933	-74.39833	5.59	15.571	31.563	8.07	6.65
27085.86			5.94	15.576	31.555	8.07	6.57
27086.61			6.25	15.571	31.554	8.07	6.52
27087.36	39.35933	-74.39833	6.35	15.576	31.557	8.07	6.45
27088.11			6.54	15.567	31.562	8.07	6.44
27088.86			6.82	15.562	31.561	8.07	6.59
27089.61	39.35933	-74.39833	6.89	15.573	31.557	8.07	6.72
27090.36			7.08	15.574	31.551	8.07	6.78
27101.44	39.35933	-74.39833	7.24	15.570	31.558	8.07	6.77

Brigantine Inlet OCTOBER 21 1994 Station A-4

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
29005.51	39.36500	-74.40334	0.68	15.580	31.515	8.11	6.91
29008.73	39.36500	-74.40334	0.72	15.583	31.520	8.11	6.89
29013.44			0.78	15.588	31.516	8.11	6.90
29014.19			0.89	15.590	31.514	8.11	6.90
29014.93	39.36500	-74.40334	0.82	15.595	31.513	8.11	6.91
29015.67			0.93	15.588	31.518	8.11	6.91
29016.42	39.36500	-74.40334	1.21	15.591	31.515	8.11	6.89
29017.16			1.43	15.593	31.511	8.11	6.89
29017.91			1.58	15.593	31.513	8.11	6.87
29018.65	39.36500	-74.40334	1.90	15.586	31.521	8.10	6.84
29019.40			2.14	15.588	31.519	8.10	6.87
29020.14			2.32	15.595	31.509	8.10	6.88
29020.88	39.36500	-74.40334	2.59	15.590	31.516	8.11	6.87
29021.63			2.85	15.597	31.507	8.10	6.88
29022.38	39.36500	-74.40334	3.10	15.591	31.517	8.10	6.94
29023.12			3.30	15.588	31.519	8.09	6.98
29023.86			3.54	15.583	31.521	8.09	6.98
29024.60	39.36500	-74.40334	3.79	15.581	31.525	8.09	6.95
29025.35			4.00	15.590	31.515	8.09	6.91
29026.09	39.36500	-74.40334	4.22	15.581	31.522	8.09	6.88
29026.84			4.48	15.586	31.515	8.09	6.88
29027.58			4.63	15.579	31.524	8.10	6.88
29028.33	39.36500	-74.40334	4.88	15.588	31.516	8.11	6.87
29029.07			5.14	15.597	31.506	8.11	6.86
29029.81			5.32	15.577	31.525	8.10	6.85
29030.56	39.36500	-74.40334	5.53	15.579	31.521	8.12	6.84
29031.30			5.84	15.590	31.516	8.15	6.84
29032.05	39.36500	-74.40334	6.04	15.592	31.511	8.14	6.85
29032.79			6.23	15.584	31.516	8.13	6.86
29033.53			6.53	15.591	31.511	8.13	6.83
29034.28	39.36500	-74.40334	6.73	15.574	31.525	8.14	6.82
29035.02			6.89	15.579	31.530	8.15	6.81
29044.62	39.36483	-74.40317	7.08	15.591	31.515	8.17	6.82

Brigantine Inlet OCTOBER 19 1994 Station A-5

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
52929.59	39.37634	-74.41116	0.12	15.653	31.415	8.09	7.23
52961.09			0.20	15.667	31.410	8.09	7.22
52961.59	39.37634	-74.41133	0.39	15.656	31.404	8.09	7.19
52962.09			0.71	15.653	31.407	8.09	7.14
52962.59			1.00	15.650	31.408	8.09	7.09
52963.09			1.31	15.648	31.403	8.09	7.10
52963.59	39.37634	-74.41133	1.51	15.645	31.402	8.09	7.17
52964.09			1.70	15.666	31.388	8.09	7.22
52964.59			1.93	15.645	31.409	8.09	7.31
52965.09			2.08	15.658	31.395	8.09	7.40
52965.59	39.37634	-74.41133	2.22	15.648	31.399	8.09	7.51
52966.09			2.44	15.640	31.406	8.09	7.58
52966.59			2.64	15.635	31.406	8.09	7.63
52967.09	39.37634	-74.41133	2.84	15.640	31.409	8.09	7.64
52967.59			2.92	15.645	31.402	8.09	7.64
52968.09			3.02	15.642	31.407	8.09	7.63
52968.59			3.17	15.659	31.387	8.09	7.63
52969.09	39.37634	-74.41133	3.31	15.648	31.395	8.09	7.66
52969.59			3.50	15.645	31.407	8.09	7.69
52970.09			3.73	15.639	31.406	8.09	7.67
52970.59			3.90	15.653	31.409	8.09	7.66
52971.09	39.37634	-74.41133	4.11	15.656	31.406	8.09	7.67
52971.59			4.25	15.653	31.415	8.09	7.70
52972.09			4.27	15.658	31.408	8.09	7.73
52972.59			4.31	15.658	31.411	8.09	7.76
52973.09			4.32	15.653	31.412	8.09	7.74
52990.22	39.37634	-74.41133					

Brigantine Inlet OCTOBER 21 1994 Station A-6

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
27130.13	39.36300	-74.39817	0.45	15.603	31.506	8.11	6.70
27133.23			0.48	15.598	31.501	8.11	6.73
27133.73			0.61	15.590	31.511	8.11	6.74
27134.22			0.69	15.587	31.513	8.11	6.77
27134.72	39.36300	-74.39817	0.86	15.595	31.508	8.11	6.80
27135.21			1.10	15.595	31.506	8.11	6.81
27135.71			1.39	15.571	31.522	8.11	6.83
27136.21			1.47	15.592	31.513	8.10	6.83
27136.70	39.36300	-74.39817	1.57	15.592	31.510	8.11	6.80
27137.20			1.75	15.601	31.502	8.10	6.79
27137.70			1.97	15.598	31.511	8.11	6.80
27138.19			2.10	15.590	31.518	8.10	6.84
27138.69	39.36300	-74.39817	2.24	15.590	31.525	8.11	6.89
27139.18			2.49	15.593	31.519	8.11	6.93
27139.68			2.65	15.600	31.517	8.11	6.99
27140.18			2.80	15.587	31.524	8.12	7.02
27140.67	39.36300	-74.39817	2.94	15.569	31.542	8.12	7.05
27141.17			3.12	15.595	31.521	8.12	7.05
27141.66			3.27	15.611	31.507	8.12	7.04
27142.16			3.41	15.593	31.522	8.12	7.03
27142.66	39.36300	-74.39817	3.57	15.598	31.521	8.12	7.04
27143.15			3.72	15.592	31.523	8.11	7.04
27143.65			3.83	15.592	31.522	8.11	7.03
27144.14			3.91	15.595	31.520	8.12	7.03
27144.64	39.36300	-74.39817	4.09	15.598	31.514	8.12	7.01
27145.14			4.20	15.598	31.514	8.11	6.99
27145.63			4.22	15.595	31.520	8.12	6.96
27146.13			4.29	15.596	31.516	8.11	6.94
27146.63	39.36300	-74.39817	4.51	15.598	31.515	8.11	6.91
27147.12			4.67	15.598	31.517	8.11	6.90
27147.62			4.70	15.601	31.519	8.11	6.90
27148.11			4.76	15.601	31.518	8.11	6.88
27148.61	39.36300	-74.39817	4.90	15.601	31.515	8.11	6.87
27149.11			5.07	15.598	31.520	8.11	6.89
27149.60			5.13	15.566	31.542	8.11	6.89
27150.10			5.14	15.600	31.515	8.12	6.91
27150.59	39.36300	-74.39817	5.14	15.595	31.523	8.11	6.89
27163.49	39.36317	-74.39817	5.17	15.555	31.556	8.11	6.88

Brigantine Inlet OCTOBER 21 1994 Station A-7

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
30906.26	39.36750	-74.40533	0.55	15.617	31.500	8.16	6.95
30909.07			1.01	15.624	31.498	8.16	6.92
30910.07	39.36750	-74.40533	1.34	15.628	31.495	8.15	6.93
30911.07			1.80	15.628	31.495	8.15	6.95
30912.07	39.36750	-74.40533	2.13	15.628	31.495	8.15	6.97
30913.07			2.58	15.635	31.490	8.15	7.00
30914.07	39.36750	-74.40533	3.02	15.628	31.494	8.15	7.06
30915.07			3.53	15.621	31.503	8.15	7.09
30916.07	39.36750	-74.40533	3.84	15.618	31.504	8.14	7.05
30917.07			4.16	15.627	31.496	8.14	7.06
30918.07	39.36750	-74.40533	4.70	15.626	31.501	8.14	7.07
30919.07			5.16	15.616	31.507	8.14	7.07
30920.07	39.36750	-74.40533	5.66	15.622	31.505	8.14	7.06
30921.07			5.95	15.624	31.505	8.14	7.03
30922.07	39.36750	-74.40533	6.33	15.613	31.511	8.14	7.00
30923.07			6.78	15.611	31.515	8.13	7.03
30924.07	39.36750	-74.40533	7.27	15.611	31.513	8.14	7.06
30925.07			7.46	15.616	31.509	8.13	7.06
30926.20			7.56	15.610	31.516	8.13	7.02
30977.45	39.36750	-74.40533					

Brigantine Inlet OCTOBER 20 1994 Station A-8

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
33415.52	39.36917	-74.40283	0.42	15.648	31.585	8.06	6.48
33420.20			0.43	15.651	31.586	8.06	6.48
33420.69			0.50	15.666	31.578	8.06	6.50
33421.18	39.36917	-74.40283	0.46	15.659	31.583	8.07	6.56
33421.67			0.53	15.651	31.583	8.06	6.59
33422.16			0.77	15.650	31.583	8.05	6.60
33422.66			1.07	15.634	31.572	8.05	6.63
33423.15	39.36917	-74.40283	1.33	15.605	31.584	8.05	6.67
33423.64			1.42	15.605	31.588	8.05	6.70
33424.13			1.48	15.602	31.587	8.05	6.69
33424.63			1.61	15.607	31.586	8.05	6.70
33425.12	39.36917	-74.40300	1.98	15.605	31.585	8.05	6.76
33425.61			2.20	15.592	31.595	8.05	6.83
33426.10			2.35	15.616	31.572	8.05	6.87
33426.59			2.46	15.597	31.594	8.05	6.90
33427.09	39.36917	-74.40300	2.61	15.602	31.586	8.05	6.93
33427.58			2.82	15.616	31.579	8.05	6.95
33428.07			2.92	15.599	31.588	8.05	6.98
33428.56			3.15	15.607	31.579	8.05	6.99
33429.05	39.36917	-74.40300	3.36	15.589	31.593	8.05	6.97
33429.55			3.58	15.586	31.585	8.05	6.93
33430.04			3.67	15.568	31.593	8.05	6.89
33430.53			3.72	15.565	31.588	8.05	6.89
33431.02	39.36917	-74.40300	3.88	15.576	31.582	8.05	6.90
33431.52			4.06	15.575	31.583	8.05	6.88
33441.23	39.36917	-74.40283	4.09	15.567	31.594	8.05	6.85

Brigantine Inlet OCTOBER 19 1994 Station A-9

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
55760.75	39.37634	-74.41150	0.01	15.933	31.484	8.09	7.70
55767.77	39.37650	-74.41167	0.12	15.938	31.484	8.09	7.69
55768.26			0.39	15.924	31.498	8.08	7.66
55768.75			0.73	15.914	31.516	8.08	7.62
55769.24			0.93	15.913	31.513	8.08	7.60
55769.73	39.37650	-74.41167	1.06	15.916	31.501	8.08	7.56
55770.23			1.28	15.889	31.483	8.08	7.56
55770.72			1.48	15.876	31.473	8.08	7.58
55771.21			1.54	15.873	31.471	8.08	7.58
55771.70	39.37650	-74.41167	1.73	15.792	31.456	8.08	7.55
55772.20			1.94	15.787	31.447	8.08	7.53
55772.69			2.11	15.782	31.457	8.08	7.52
55773.18			2.34	15.782	31.454	8.08	7.49
55773.67	39.37650	-74.41167	2.51	15.790	31.457	8.08	7.46
557-74.16			2.72	15.776	31.440	8.09	7.44
557-74.66			2.98	15.752	31.445	8.09	7.42
55775.15			3.20	15.760	31.443	8.09	7.43
55775.64	39.37650	-74.41167	3.44	15.757	31.441	8.09	7.39
55776.13			3.64	15.765	31.446	8.10	7.30
55776.63			3.76	15.774	31.442	8.10	7.25
55777.12			3.80	15.768	31.450	8.10	7.21
55777.61	39.37650	-74.41167	3.79	15.771	31.445	8.10	7.17
55778.10			3.83	15.755	31.463	8.10	7.09
55778.59			3.88	15.771	31.448	8.09	7.00
55779.09			3.95	15.771	31.444	8.10	6.97
55779.58	39.37650	-74.41167	4.02	15.773	31.442	8.09	6.97
55780.07			4.06	15.773	31.446	8.10	6.96
55780.56			4.11	15.774	31.445	8.10	6.92
55781.05			4.14	15.768	31.450	8.09	6.88
55792.01	39.37650	-74.41150	4.17	15.771	31.430	8.10	6.86

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Brigantine Inlet OCTOBER 19 1994 Station A-10

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
33564.75	39.36133	-74.39217	0.91	15.639	31.642	7.97	7.08
33567.50	39.36117	-74.39217	1.01	15.630	31.652	7.97	7.08
33568.25			0.97	15.632	31.648	7.97	7.09
33569.00			1.11	15.656	31.641	7.97	7.07
33569.75	39.36117	-74.39217	1.36	15.645	31.644	7.97	7.03
33570.50			1.52	15.607	31.663	7.97	7.01
33571.25			1.67	15.625	31.653	7.97	6.99
33572.00	39.36117	-74.39217	1.78	15.620	31.652	7.97	6.97
33572.75			1.92	15.625	31.646	7.97	7.00
33573.50	39.36117	-74.39217	1.88	15.618	31.661	7.97	6.98
335-74.25			1.99	15.629	31.653	7.97	6.98
33575.00			2.31	15.604	31.649	7.97	7.01
33575.75	39.36117	-74.39217	2.32	15.599	31.649	7.97	7.04
33576.50			2.35	15.600	31.647	7.98	7.04
33577.25			2.55	15.601	31.649	7.98	7.03
33578.00	39.36117	-74.39217	2.64	15.597	31.657	7.98	7.01
33578.75			2.85	15.599	31.648	7.98	6.96
33579.50	39.36117	-74.39217	3.06	15.592	31.654	7.98	6.93
33580.25			3.17	15.590	31.649	7.98	6.90
33581.00			3.43	15.576	31.657	7.98	6.89
33581.75	39.36117	-74.39217	3.45	15.579	31.653	7.98	6.87
33582.50			3.56	15.579	31.647	7.99	6.88
33583.25	39.36117	-74.39217	3.96	15.578	31.637	7.98	6.89
33584.00			4.13	15.565	31.644	7.98	6.90
33584.75			4.26	15.563	31.644	7.98	6.94
33585.50	39.36117	-74.39217	4.57	15.560	31.643	7.98	6.94
33586.25			4.39	15.563	31.641	7.98	6.93
33587.00			4.43	15.569	31.639	7.99	6.92
33587.75	39.36117	-74.39217	4.73	15.567	31.638	7.99	6.90
33588.50			4.88	15.567	31.639	7.99	6.90
33589.25	39.36117	-74.39217	4.85	15.558	31.650	7.99	6.93
33590.00			5.03	15.572	31.639	7.99	6.90
33590.75			4.91	15.565	31.642	7.99	6.88
33591.50			4.83	15.565	31.651	7.99	6.87
33592.25			5.13	15.560	31.637	7.99	6.87
33593.00			5.24	15.543	31.648	7.99	6.87
33593.75	39.36117	-74.39217	5.17	15.547	31.642	7.99	6.85
33594.50			5.35	15.538	31.649	7.99	6.88
33595.25	39.36117	-74.39217	5.65	15.540	31.639	7.99	6.92
33596.00			5.67	15.538	31.637	8.00	6.93
33596.75			5.77	15.551	31.630	8.00	6.96
33597.50	39.36117	-74.39217	6.08	15.535	31.640	8.00	6.99
33598.25			6.27	15.540	31.636	8.01	7.00
33599.00	39.36117	-74.39217	6.29	15.528	31.643	8.03	6.94
33599.75			6.32	15.526	31.639	8.05	6.93
33600.50			6.36	15.531	31.640	8.05	6.95
33601.25	39.36117	-74.39217	6.56	15.524	31.641	8.06	6.91
33624.13	39.36117	-74.39217	6.65	15.535	31.639	8.06	6.88

Brigantine Inlet OCTOBER 19 1994 Station A-10

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L

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Brigantine Inlet OCTOBER 21 1994 Station A-11

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
28145.23	39.36567	-74.40217	0.25	15.593	31.491	8.15	6.96
28150.32			0.31	15.588	31.498	8.14	6.96
28151.18			0.43	15.588	31.495	8.14	6.95
28151.68			0.64	15.598	31.494	8.14	6.95
28152.18	39.36567	-74.40217	0.80	15.598	31.497	8.14	6.93
28152.67			0.94	15.601	31.488	8.14	6.89
28153.17			1.13	15.585	31.504	8.14	6.87
28153.66			1.34	15.599	31.486	8.14	6.87
28154.16	39.36567	-74.40217	1.54	15.596	31.495	8.13	6.89
28154.66			1.81	15.601	31.492	8.13	6.91
28155.15			2.01	15.596	31.495	8.13	6.94
28155.65			2.09	15.604	31.488	8.13	6.95
28156.14	39.36567	-74.40217	2.22	15.601	31.491	8.14	6.94
28156.64			2.44	15.596	31.498	8.13	6.92
28157.14			2.60	15.593	31.504	8.14	6.92
28157.63			2.76	15.599	31.492	8.14	6.95
28158.13	39.36567	-74.40217	2.94	15.593	31.500	8.15	6.97
28158.63			3.10	15.596	31.495	8.15	7.00
28159.12			3.30	15.607	31.493	8.15	7.02
28159.62			3.53	15.598	31.496	8.16	7.03
28160.11	39.36567	-74.40217	3.66	15.588	31.501	8.16	7.04
28160.61			3.76	15.583	31.508	8.17	7.04
28161.11			3.93	15.599	31.499	8.17	7.02
28161.60			4.08	15.596	31.497	8.18	7.01
28162.10	39.36567	-74.40217	4.22	15.580	31.510	8.19	7.01
28162.59			4.37	15.595	31.498	8.20	7.00
28163.09			4.52	15.601	31.497	8.21	7.00
28163.59			4.68	15.593	31.499	8.22	6.98
28164.08	39.36567	-74.40217	4.78	15.596	31.497	8.23	6.96
28164.58			4.94	15.590	31.498	8.23	6.95
28165.07			5.16	15.596	31.497	8.22	6.93
28165.57			5.36	15.601	31.486	8.22	6.89
28166.07	39.36567	-74.40217	5.42	15.580	31.510	8.22	6.87
28183.31	39.36567	-74.40234					

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Brigantine Inlet OCTOBER 20 1994 Station A-12

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
30747.67	39.36934	-74.40633	0.13	15.621	31.550	8.07	6.79
30756.55			0.16	15.618	31.561	8.07	6.79
30757.05			0.38	15.615	31.560	8.06	6.75
30757.55	39.36917	-74.40633	0.67	15.599	31.569	8.06	6.74
30758.05			0.90	15.602	31.556	8.06	6.77
30758.55			1.11	15.605	31.557	8.06	6.81
30759.05			1.25	15.594	31.562	8.06	6.86
30759.55	39.36917	-74.40633	1.48	15.591	31.564	8.05	6.89
30760.05			1.62	15.589	31.566	8.05	6.90
30760.55			1.77	15.605	31.556	8.05	6.90
30761.05			1.95	15.589	31.566	8.05	6.90
30761.55	39.36917	-74.40633	2.11	15.591	31.564	8.06	6.89
30762.05			2.32	15.589	31.562	8.06	6.90
30762.55			2.44	15.591	31.557	8.06	6.92
30763.05			2.49	15.589	31.562	8.06	6.95
30763.55	39.36934	-74.40633	2.65	15.602	31.551	8.07	6.94
30764.05			2.78	15.581	31.568	8.06	6.92
30764.55			2.92	15.586	31.568	8.06	6.91
30765.05			3.03	15.589	31.562	8.06	6.93
30765.55	39.36934	-74.40633	3.14	15.594	31.557	8.06	6.93
30766.05			3.29	15.597	31.555	8.06	6.93
30766.55			3.51	15.588	31.562	8.06	6.95
30767.05			3.76	15.589	31.562	8.06	6.97
30767.55	39.36934	-74.40633	3.92	15.591	31.556	8.05	6.99
30768.05			4.06	15.586	31.564	8.06	7.02
30768.55			4.29	15.583	31.566	8.05	7.03
30769.05			4.49	15.594	31.557	8.06	7.04
30769.55	39.36934	-74.40633	4.68	15.594	31.561	8.06	7.05
30770.05			4.91	15.584	31.568	8.06	7.05
30770.55			5.11	15.586	31.564	8.06	7.03
30771.05			5.30	15.588	31.562	8.06	7.01
30771.55	39.36934	-74.40633	5.49	15.583	31.570	8.06	6.99
30772.05			5.61	15.592	31.562	8.06	6.99
30772.55			5.79	15.584	31.568	8.06	7.00
30773.05			5.98	15.586	31.561	8.06	6.99
30773.55	39.36934	-74.40633	6.15	15.586	31.566	8.06	6.96
307-74.05			6.40	15.596	31.559	8.06	6.95
307-74.55			6.58	15.589	31.564	8.07	6.95
30775.05			6.59	15.586	31.563	8.06	6.94
30775.55	39.36934	-74.40633	6.58	15.597	31.558	8.07	6.94
30776.05			6.60	15.589	31.560	8.07	6.93
30776.55			6.67	15.589	31.564	8.06	6.91
30777.05			6.76	15.599	31.556	8.06	6.91
30777.55	39.36934	-74.40633	6.79	15.586	31.564	8.06	6.92
30778.05			6.86	15.589	31.564	8.07	6.92
30778.55			6.95	15.589	31.561	8.07	6.91
30808.17	39.36934	-74.40633					

Brigantine Inlet OCTOBER 19 1994 Station A-13

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
35403.93	39.36033	-74.39450	0.74	15.179	31.534	8.00	7.65
35421.05	39.36050	-74.39433	0.87	15.184	31.531	8.00	7.24
35422.18			1.00	15.179	31.536	8.00	7.05
35423.18	39.36050	-74.39433	1.05	15.175	31.538	8.00	6.99
35424.18			1.06	15.176	31.537	8.00	6.97
35425.18	39.36050	-74.39433	1.09	15.168	31.542	8.00	6.93
35426.18			1.11	15.165	31.534	8.00	6.98
35427.18	39.36050	-74.39433	1.12	15.159	31.539	8.00	6.98
35428.18			1.15	15.161	31.531	8.00	7.03
35429.18	39.36050	-74.39433	1.30	15.155	31.538	8.00	7.07
35430.18			1.20	15.158	31.531	8.00	7.10
35431.18	39.36050	-74.39433	1.16	15.149	31.538	8.00	7.12
35432.18			1.33	15.151	31.541	8.00	7.07
35433.18	39.36050	-74.39433	1.14	15.153	31.531	8.00	7.01
35434.18			1.30	15.148	31.540	8.00	7.01
35435.18	39.36033	-74.39433	1.27	15.182	31.527	8.00	7.05
35436.18			1.28	15.170	31.535	8.00	7.06
35437.18	39.36033	-74.39433	1.64	15.158	31.538	8.00	7.06
35438.18			1.87	15.157	31.536	8.00	7.05
35439.18	39.36033	-74.39433	2.17	15.143	31.540	8.00	7.09
35440.18			2.26	15.144	31.534	8.00	7.01
35441.18	39.36033	-74.39433	2.45	15.139	31.542	8.00	7.00
35442.18			2.64	15.138	31.541	8.00	7.03
35443.18	39.36033	-74.39433	2.80	15.130	31.542	8.00	7.07
35444.18			2.84	15.122	31.541	8.01	7.07
35445.18	39.36033	-74.39433	3.31	15.126	31.536	8.04	7.10
35446.18			3.21	15.127	31.537	8.04	7.04
35447.18	39.36033	-74.39433	3.44	15.126	31.538	8.04	7.02
35448.18			3.45	15.121	31.542	8.03	7.06
35449.18	39.36050	-74.39450	3.48	15.130	31.532	8.03	7.02
35450.18			3.43	15.138	31.537	8.03	7.01
35451.18	39.36050	-74.39450	3.70	15.134	31.537	8.03	6.99
35452.18			3.65	15.134	31.542	8.04	7.00
35453.18	39.36050	-74.39450	3.80	15.129	31.540	8.04	6.98
35454.18			4.05	15.131	31.540	8.07	6.95
35455.18	39.36050	-74.39450	4.28	15.121	31.543		6.93
35456.18			4.44	15.127	31.540		6.92
35457.18	39.36050	-74.39450	4.70	15.119	31.543	8.08	6.94
35458.18			4.90	15.121	31.538	8.06	6.94
35459.18	39.36050	-74.39450	5.14	15.125	31.534	8.06	6.93
35475.68	39.36050	-74.39433	5.24	15.114	31.542	8.06	6.90

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Brigantine Inlet OCTOBER 20 1994 Station A-14

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
28952.79	39.37100	-74.40750	0.12	15.559	31.576	8.08	6.68
28960.04			0.28	15.552	31.580	8.07	6.69
28960.79	39.37100	-74.40733	0.60	15.555	31.581	8.07	6.70
28961.54			0.83	15.558	31.574	8.07	6.74
28962.29			1.07	15.551	31.577	8.07	6.80
28963.04	39.37100	-74.40733	1.19	15.555	31.578	8.07	6.82
28963.79			1.39	15.551	31.584	8.07	6.81
28964.54	39.37100	-74.40733	1.73	15.558	31.574	8.07	6.86
28965.29			2.13	15.550	31.580	8.07	6.93
28966.04			2.46	15.543	31.590	8.07	6.97
28966.79	39.37100	-74.40733	2.76	15.549	31.587	8.07	6.95
28967.54			3.08	15.550	31.579	8.07	6.87
28968.29			3.23	15.555	31.576	8.06	6.85
28969.04	39.37100	-74.40733	3.22	15.555	31.580	8.06	6.87
28969.79			3.15	15.548	31.581	8.06	6.86
28970.54	39.37100	-74.40733	3.16	15.551	31.578	8.06	6.85
28971.29			3.29	15.553	31.579	8.06	6.84
28972.04			3.50	15.555	31.575	8.06	6.82
28972.79	39.37100	-74.40733	3.63	15.548	31.586	8.06	6.79
28973.54			3.65	15.551	31.583	8.06	6.77
289-74.29			3.88	15.549	31.582	8.06	6.73
28975.04	39.37100	-74.40733	4.10	15.551	31.583	8.06	6.72
28975.79			4.27	15.555	31.580	8.06	6.69
28976.54	39.37100	-74.40733	4.53	15.557	31.578	8.06	6.64
28977.29			4.74	15.564	31.570	8.06	6.65
28978.04			4.83	15.543	31.589	8.06	6.69
28978.79	39.37100	-74.40733	4.95	15.544	31.583	8.06	6.74
28979.54			4.95	15.555	31.577	8.06	6.79
28980.29			5.18	15.548	31.587	8.06	6.83
28981.04			5.45	15.544	31.590	8.06	6.81
28981.79			5.68	15.578	31.567	8.06	6.83
28982.54	39.37100	-74.40733	5.77	15.564	31.572	8.06	6.84
28983.29			5.76	15.567	31.576	8.06	6.82
28984.04			6.01	15.564	31.579	8.06	6.83
28984.79	39.37100	-74.40733	6.39	15.563	31.579	8.06	6.82
28985.54			6.73	15.567	31.566	8.07	6.85
28997.71	39.37100	-74.40733	6.82	15.567	31.560	8.07	6.91

Brigantine Inlet OCTOBER 20 1994 Station A-15

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
29812.96	39.37117	-74.40750	0.20	15.573	31.568	8.07	6.87
29814.69			0.29	15.568	31.572	8.07	6.88
29815.18			0.51	15.562	31.578	8.07	6.89
29815.67			0.75	15.565	31.575	8.07	6.90
29816.16	39.37117	-74.40750	0.92	15.559	31.583	8.07	6.92
29816.65			0.96	15.554	31.584	8.07	6.93
29817.15			1.07	15.557	31.585	8.07	6.92
29817.64			1.14	15.552	31.589	8.07	6.92
29818.13	39.37117	-74.40750	1.23	15.544	31.592	8.06	6.96
29818.62			1.35	15.549	31.584	8.07	7.00
29819.12			1.46	15.546	31.586	8.06	7.03
29819.61			1.58	15.546	31.590	8.06	7.05
29820.10	39.37117	-74.40750	1.78	15.549	31.588	8.06	7.06
29820.59			1.88	15.554	31.577	8.06	7.06
29821.08			1.98	15.546	31.586	8.06	7.05
29821.58			2.12	15.543	31.582	8.06	7.01
29822.07	39.37117	-74.40750	2.29	15.538	31.589	8.07	6.98
29822.56			2.51	15.530	31.593	8.07	6.95
29823.05			2.62	15.530	31.588	8.07	6.93
29823.54			2.79	15.538	31.589	8.07	6.93
29824.04	39.37117	-74.40750	2.86	15.532	31.587	8.06	6.92
29824.53			2.86	15.535	31.588	8.07	6.89
29825.02			2.94	15.546	31.579	8.06	6.87
29825.51			3.01	15.538	31.585	8.07	6.87
29826.01	39.37117	-74.40750	3.15	15.530	31.574	8.06	6.90
29826.50			3.29	15.533	31.586	8.06	6.93
29826.99			3.37	15.533	31.586	8.06	6.92
29827.48			3.41	15.530	31.596	8.06	6.91
29827.97	39.37117	-74.40750	3.55	15.546	31.572	8.06	6.92
29828.47			3.62	15.538	31.581	8.06	6.92
29828.96			3.58	15.530	31.585	8.06	6.93
29829.45			3.56	15.527	31.580	8.06	6.93
29829.94	39.37117	-74.40750	3.75	15.538	31.574	8.06	6.93
29830.44			4.00	15.541	31.575	8.06	6.92
29830.93			4.25	15.533	31.586	8.06	6.89
29831.42			4.47	15.536	31.580	8.06	6.86
29831.91	39.37117	-74.40750	4.65	15.525	31.585	8.06	6.84
29832.40			4.85	15.535	31.576	8.06	6.83
29832.90			5.05	15.528	31.586	8.06	6.83
29833.39			5.13	15.525	31.584	8.06	6.87
29833.88	39.37117	-74.40750	5.25	15.533	31.574	8.06	6.86
29834.37			5.40	15.527	31.583	8.06	6.82
29834.87			5.53	15.517	31.594	8.06	6.82
29835.36	39.37117	-74.40750	5.59	15.536	31.576	8.06	6.88
29863.29	39.37133	-74.40733					

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Brigantine Inlet OCTOBER 20 1994 Station A-16

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
26380.66	39.36150	-74.39850	0.02	15.541	31.581	8.07	6.93
26385.13			0.16	15.586	31.545	8.06	6.96
26385.63			0.51	15.567	31.552	8.06	6.97
26386.12	39.36150	-74.39850	0.79	15.570	31.553	8.06	6.96
26386.62			0.99	15.562	31.553	8.06	6.94
26387.11			1.22	15.562	31.559	8.06	6.92
26387.61			1.48	15.560	31.558	8.06	6.94
26388.11	39.36150	-74.39850	1.74	15.570	31.550	8.06	6.97
26388.60			1.88	15.578	31.543	8.05	6.99
26389.10			2.07	15.581	31.541	8.05	6.96
26389.59			2.19	15.562	31.557	8.05	6.91
26390.09	39.36150	-74.39850	2.32	15.562	31.555	8.06	6.86
26390.59			2.54	15.573	31.544	8.06	6.85
26391.08			2.79	15.562	31.559	8.06	6.83
26391.58			3.02	15.568	31.554	8.06	6.78
26392.07	39.36150	-74.39850	3.13	15.565	31.553	8.06	6.71
26392.57			3.30	15.570	31.549	8.06	6.62
26393.07			3.60	15.565	31.546	8.06	6.53
26393.56			3.83	15.567	31.551	8.05	6.49
26394.06	39.36150	-74.39850	3.89	15.570	31.549	8.05	6.55
26394.55			3.89	15.581	31.537	8.06	6.67
26395.05			3.93	15.573	31.547	8.06	6.84
26395.55			4.03	15.549	31.569	8.06	6.98
26396.04	39.36150	-74.39850	4.30	15.573	31.550	8.06	7.06
26396.54			4.59	15.567	31.554	8.06	7.12
26397.04			4.82	15.568	31.550	8.06	7.15
26397.53			4.99	15.570	31.548	8.06	7.18
26398.03	39.36150	-74.39850	5.14	15.565	31.556	8.06	7.17
26398.52			5.30	15.573	31.546	8.06	7.15
26399.02			5.34	15.554	31.558	8.06	7.16
26399.52			5.48	15.562	31.551	8.06	7.16
26400.01	39.36150	-74.39850	5.57	15.573	31.549	8.06	7.13
26400.51			5.71	15.575	31.547	8.06	7.09
26401.00			5.91	15.575	31.544	8.05	7.04
26427.92	39.36150	-74.39867					

Brigantine Inlet OCTOBER 20 1994 Station B-1

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
48972.39	39.34667	-74.39700	0.87	15.879	31.554	8.04	6.90
48976.52			0.97	15.868	31.562	8.04	6.89
48977.02	39.34667	-74.39700	1.26	15.884	31.542	8.04	6.88
48977.52			1.46	15.882	31.551	8.04	6.90
48978.02			1.64	15.852	31.551	8.04	6.91
48978.52			2.01	15.800	31.557	8.03	6.91
48979.02	39.34667	-74.39700	2.30	15.766	31.545	8.04	6.88
48979.52			2.56	15.726	31.560	8.04	6.86
48980.02			2.75	15.731	31.553	8.04	6.85
48980.52			2.98	15.728	31.551	8.04	6.83
48981.02	39.34667	-74.39700	3.28	15.731	31.545	8.04	6.80
48981.52			3.62	15.728	31.544	8.04	6.80
48982.02			3.89	15.715	31.555	8.04	6.86
48982.52			4.13	15.704	31.557	8.03	6.91
48983.02	39.34667	-74.39700	4.31	15.701	31.566	8.04	6.92
48983.52			4.57	15.696	31.563	8.04	6.90
48984.02			4.72	15.706	31.562	8.03	6.93
48984.52			4.88	15.704	31.559	8.03	6.93
48985.02	39.34667	-74.39716	5.18	15.690	31.574	8.04	6.92
48985.52			5.53	15.704	31.565	8.04	6.87
48986.02			5.70	15.704	31.566	8.03	6.80
48986.52			5.68	15.704	31.569	8.04	6.77
48987.02	39.34667	-74.39716	5.82	15.709	31.569	8.03	6.76
48987.52			6.14	15.718	31.565	8.03	6.73
48988.02			6.50	15.712	31.566	8.03	6.68
48988.52			6.87	15.720	31.566	8.03	6.63
48989.02	39.34667	-74.39716	7.22	15.715	31.567	8.03	6.59
48989.52			7.46	15.720	31.560	8.03	6.59
48990.02			7.48	15.725	31.562	8.03	6.63
48990.52			7.53	15.731	31.554	8.03	6.70
48991.02	39.34667	-74.39716	7.53	15.728	31.557	8.03	6.79
48991.52			7.30	15.728	31.556	8.03	6.80
48992.02			7.31	15.731	31.554	8.03	6.78
48992.52			7.53	15.723	31.557	8.03	6.74
49013.52	39.34658	-74.39716	7.58	15.728	31.553	8.03	6.74

Brigantine Inlet OCTOBER 20 1994 Station B-2

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
41432.75	39.34917	-74.39817	0.17	15.705	31.556	8.04	6.53
41434.58			0.24	15.719	31.546	8.04	6.60
41435.33	39.34917	-74.39817	0.60	15.718	31.544	8.03	6.63
41436.08			0.86	15.714	31.550	8.03	6.64
41436.83	39.34917	-74.39817	1.06	15.704	31.556	8.03	6.66
41437.58			1.26	15.711	31.548	8.02	6.74
41438.33			1.49	15.709	31.549	8.03	6.81
41439.08	39.34917	-74.39817	1.69	15.700	31.552	8.03	6.87
41439.83			1.87	15.700	31.554	8.03	6.92
41440.58			1.95	15.704	31.553	8.03	6.94
41441.33	39.34917	-74.39833	2.25	15.693	31.557	8.03	6.94
41442.08			2.34	15.698	31.551	8.04	6.88
41442.83	39.34917	-74.39817	2.48	15.704	31.545	8.04	6.86
41443.58			2.68	15.696	31.550	8.05	6.86
41444.33			2.77	15.696	31.554	8.04	6.86
41445.08	39.34917	-74.39817	2.89	15.686	31.558	8.05	6.85
41445.83			3.24	15.700	31.549	8.05	6.76
41446.58			3.42	15.689	31.555	8.05	6.71
41447.33	39.34917	-74.39833	3.52	15.691	31.554	8.05	6.71
41448.08			3.78	15.688	31.554	8.04	6.71
41448.83	39.34917	-74.39833	3.91	15.684	31.556	8.04	6.75
41449.58			4.02	15.686	31.550	8.04	6.76
41450.33			4.18	15.686	31.558	8.04	6.75
41451.08	39.34917	-74.39833	4.29	15.691	31.551	8.04	6.76
41451.83			4.45	15.684	31.557	8.04	6.78
41452.58			4.68	15.689	31.552	8.04	6.74
41453.33	39.34917	-74.39850	4.83	15.693	31.547	8.04	6.73
41454.08			5.01	15.685	31.558	8.04	6.77
41454.83	39.34900	-74.39850	5.29	15.687	31.545	8.04	6.78
41455.58			5.43	15.684	31.554	8.04	6.79
41456.33			5.54	15.682	31.557	8.05	6.80
41457.08	39.34900	-74.39833	5.60	15.673	31.562	8.05	6.85
41457.83			5.84	15.687	31.547	8.05	6.82
41458.58	39.34900	-74.39833	6.12	15.682	31.552	8.06	6.81
41459.33			6.22	15.688	31.548	8.05	6.81
41460.08			6.27	15.681	31.556	8.05	6.78
41460.83	39.34900	-74.39833	6.38	15.688	31.548	8.05	6.77
41461.58			6.52	15.681	31.551	8.05	6.80
41462.33			6.83	15.682	31.550	8.05	6.75
41463.08	39.34883	-74.39833	7.19	15.673	31.557	8.04	6.71
414-74.58	39.34900	-74.39850	7.44	15.678	31.551	8.04	6.69

Brigantine Inlet OCTOBER 19 1994 Station B-3

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
51277.32	39.34517	-74.39733	0.10	15.669	31.569	8.03	6.92
51301.70	39.34500	-74.39733	0.22	15.653	31.574	8.03	6.93
51302.20			0.40	15.645	31.580	8.03	6.97
51302.70			0.51	15.658	31.566	8.02	6.98
51303.20			0.70	15.656	31.568	8.02	6.98
51303.70	39.34500	-74.39733	0.98	15.661	31.571	8.01	7.01
51304.20			1.23	15.658	31.574	8.01	7.04
51304.70			1.36	15.656	31.578	8.01	7.02
51305.20			1.40	15.656	31.571	8.01	7.00
51305.70	39.34500	-74.39733	1.54	15.656	31.568	8.01	7.01
51306.20			1.84	15.639	31.571	8.01	7.02
51306.70			1.98	15.645	31.566	8.01	7.02
51307.20			2.02	15.640	31.567	8.01	7.01
51307.70	39.34500	-74.39750	2.03	15.640	31.570	8.01	7.01
51308.20			2.23	15.637	31.565	8.01	7.03
51308.70			2.51	15.629	31.568	8.01	7.04
51309.20			2.64	15.632	31.573	8.01	7.06
51309.70	39.34500	-74.39750	2.74	15.629	31.572	8.02	7.09
51310.20			2.81	15.629	31.575	8.02	7.15
51310.70			2.83	15.626	31.573	8.02	7.19
51311.20	39.34500	-74.39750	3.02	15.624	31.569	8.02	7.18
51311.70			3.19	15.610	31.572	8.02	7.14
51312.20			3.34	15.592	31.566	8.02	7.13
51312.70			3.45	15.594	31.564	8.02	7.12
51313.20	39.34500	-74.39750	3.59	15.589	31.568	8.02	7.09
51313.70			3.62	15.595	31.563	8.02	7.04
51314.20			3.73	15.578	31.573	8.02	6.99
51314.70			3.86	15.586	31.571	8.02	6.99
51315.20	39.34500	-74.39750	4.00	15.581	31.567	8.02	7.01
51315.70			4.29	15.533	31.568	8.01	7.01
51316.20			4.45	15.528	31.557	8.02	6.98
51316.70			4.48	15.539	31.549	8.02	6.98
51317.20	39.34500	-74.39750	4.46	15.546	31.553	8.02	6.98
51317.70			4.50	15.525	31.566	8.02	6.96
51318.20			4.73	15.520	31.521	8.02	6.95
51318.70			5.01	15.369	31.526	8.02	6.91
51319.20	39.34500	-74.39750	5.15	15.351	31.538	8.02	6.84
51319.70			5.08	15.364	31.535	8.02	6.82
51320.45			5.09	15.346	31.548	8.02	6.79
51320.95			5.28	15.348	31.547	8.01	6.76
51321.45	39.34500	-74.39750	5.53	15.359	31.524	8.01	6.75
51321.95			5.63	15.342	31.534	8.02	6.78
51322.45			5.47	15.359	31.534	8.01	6.80
51322.95			5.53	15.351	31.537	8.01	6.81
51323.45	39.34500	-74.39750	5.75	15.345	31.546	8.01	6.81
51323.95			5.95	15.345	31.560	8.02	6.80
51361.57	39.34500	-74.39750					

Brigantine Inlet OCTOBER 20 1994 Station B-4

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
43194.53	39.34800	-74.40283	0.13	15.771	31.556	8.04	6.44
43197.36			0.23	15.774	31.547	8.04	6.45
43197.85			0.39	15.768	31.559	8.04	6.46
43198.34			0.58	15.774	31.551	8.04	6.46
43198.84	39.34800	-74.40283	0.75	15.760	31.562	8.03	6.43
43199.33			0.91	15.742	31.565	8.03	6.41
43199.82			1.11	15.742	31.545	8.03	6.45
43200.31			1.36	15.709	31.560	8.03	6.55
43200.80	39.34800	-74.40283	1.62	15.704	31.567	8.03	6.64
43201.30			1.79	15.696	31.564	8.03	6.71
43201.79			1.97	15.699	31.565	8.03	6.78
43202.28			2.16	15.693	31.570	8.03	6.78
43202.77	39.34800	-74.40283	2.38	15.703	31.562	8.03	6.75
43203.27			2.62	15.704	31.570	8.03	6.69
43203.76			2.80	15.707	31.569	8.03	6.61
43204.25			2.88	15.720	31.561	8.03	6.59
43204.74	39.34800	-74.40283	2.89	15.702	31.572	8.03	6.59
43205.23			3.02	15.715	31.565	8.03	6.58
43205.73			3.27	15.707	31.568	8.03	6.56
43206.22			3.55	15.701	31.573	8.03	6.56
43206.71	39.34800	-74.40283	3.91	15.715	31.562	8.03	6.58
43207.20			4.26	15.715	31.569	8.03	6.62
43207.70			4.56	15.696	31.580	8.03	6.60
43208.19			4.78	15.736	31.555	8.03	6.54
43208.68	39.34800	-74.40283	4.94	15.712	31.570	8.03	6.42
43209.17			5.17	15.709	31.577	8.03	6.36
43209.66			5.24	15.696	31.583	8.03	6.34
43210.16			5.38	15.715	31.564	8.03	6.33
43210.65	39.34817	-74.40283	5.64	15.709	31.577	8.03	6.32
43211.14			5.83	15.723	31.561	8.03	6.28
43211.63			5.92	15.726	31.559	8.03	6.24
43212.13			6.12	15.709	31.572	8.03	6.17
43212.62	39.34817	-74.40283	6.38	15.723	31.579	8.03	6.12
43213.11			6.51	15.726	31.576	8.03	6.07
43213.60			6.51	15.731	31.573	8.03	6.06
43214.09			6.54	15.725	31.577	8.03	6.03
43214.59	39.34817	-74.40283	6.69	15.741	31.574	8.03	6.01
43215.08			6.72	15.731	31.586	8.03	6.01
43241.04	39.34817	-74.40300					

Brigantine Inlet OCTOBER 19 1994 Station B-5

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
46292.82	39.34333	-74.39392	0.38	15.874	31.599	7.75	6.76
46309.99			0.61	15.863	31.607	7.75	6.72
46310.74			0.93	15.863	31.616	7.76	6.70
46311.49	39.34333	-74.39417	1.33	15.874	31.607	7.76	6.72
46312.24			1.76	15.867	31.580	7.77	6.77
46312.99			2.00	15.800	31.594	7.78	6.77
46313.74	39.34317	-74.39417	2.12	15.759	31.612	7.78	6.74
46314.49			2.34	15.738	31.598	7.79	6.67
46315.24	39.34317	-74.39400	2.57	15.705	31.612	7.81	6.64
46315.99			2.80	15.700	31.609	7.82	6.63
46316.74			3.08	15.695	31.611	7.83	6.54
46317.49	39.34317	-74.39400	3.54	15.690	31.610	7.83	6.38
46318.24			3.82	15.679	31.619	7.84	6.43
46318.99			4.12	15.672	31.610	7.84	6.56
46319.74	39.34317	-74.39400	4.27	15.674	31.613	7.85	6.70
46320.49			4.38	15.681	31.600	7.86	6.83
46321.24	39.34317	-74.39400	4.71	15.663	31.615	7.87	6.85
46321.99			4.56	15.680	31.608	7.87	6.80
46322.74			4.63	15.670	31.614	7.88	6.70
46323.49	39.34317	-74.39400	5.22	15.672	31.610	7.88	6.64
46324.24			5.44	15.674	31.615	7.89	6.62
46324.99			5.31	15.675	31.612	7.90	6.56
46325.74	39.34317	-74.39400	5.64	15.672	31.614	7.90	6.55
46326.74			5.93	15.672	31.619	7.91	6.55
46327.49	39.34317	-74.39400	5.90	15.675	31.614	7.91	6.54
46328.24			6.17	15.677	31.617	7.92	6.56
46328.99			6.32	15.679	31.616	7.92	6.59
46329.74	39.34317	-74.39400	6.36	15.675	31.617	7.92	6.50
46330.49			6.76	15.673	31.625	7.92	6.45
46331.24	39.34317	-74.39400	6.98	15.675	31.620	7.93	6.48
46331.99			6.70	15.679	31.620	7.93	6.40
46332.74			6.86	15.675	31.621	7.93	6.39
46333.49	39.34317	-74.39400	7.35	15.682	31.624	7.94	6.43
46334.24			7.41	15.679	31.627	7.94	6.41
46334.99			7.32	15.684	31.628	7.94	6.45
46335.74	39.34317	-74.39400	7.56	15.688	31.617	7.95	6.47
46336.49			7.80	15.689	31.621	7.95	6.37
46337.24	39.34317	-74.39400	7.75	15.682	31.624	7.95	6.34
46337.99			7.80	15.684	31.625	7.95	6.43
46383.74	39.34317	-74.39384					

Brigantine Inlet OCTOBER 20 1994 Station B-6

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
45438.59	39.34517	-74.40683	0.13	16.225	31.631	8.06	9.35
45441.26	39.34517	-74.40700	0.31	16.224	31.628	8.06	9.14
45442.01			0.40	16.226	31.637	8.06	8.82
45442.76			0.45	16.232	31.630	8.06	8.51
45443.51	39.34517	-74.40683	0.98	16.221	31.625	8.06	8.36
45444.26			1.46	16.192	31.637	8.05	8.11
45445.01	39.34533	-74.40683	1.80	16.179	31.637	8.05	7.79
45445.76			1.98	16.175	31.639	8.05	7.37
45446.51			2.17	16.183	31.630	8.05	7.18
45447.26	39.34533	-74.40683	2.33	16.175	31.627	8.05	7.06
45448.01			2.70	16.168	31.630	8.05	7.05
45448.76			3.11	16.124	31.632	8.05	7.10
45449.51	39.34533	-74.40683	3.13	16.109	31.640	8.05	7.19
45450.26			3.41	16.071	31.626	8.05	7.31
45451.01	39.34533	-74.40700	3.58	16.017	31.618	8.06	7.41
45451.76			3.35	16.044	31.606	8.05	7.46
45452.51			3.44	16.051	31.625	8.05	7.49
45453.26	39.34533	-74.40700	3.94	15.951	31.594	8.06	7.53
45454.01			4.27	15.890	31.596	8.05	7.58
45454.76	39.34533	-74.40700	4.37	15.869	31.613	8.05	7.59
45455.51			4.69	15.800	31.598	8.05	7.53
45456.26			4.81	15.802	31.597	8.05	7.51
45457.01	39.34533	-74.40683	4.82	15.820	31.594	8.05	7.48
45457.76			5.11	15.815	31.596	8.05	7.48
45458.51			5.43	15.788	31.605	8.05	7.50
45459.26	39.34533	-74.40683	5.58	15.777	31.619	8.05	7.58
45460.01			5.77	15.773	31.608	8.05	7.58
45460.76	39.34533	-74.40683	6.04	15.763	31.616	8.05	7.50
45461.51			6.13	15.780	31.607	8.05	7.46
45462.26			6.30	15.777	31.616	8.04	7.38
45463.01	39.34517	-74.40683	6.56	15.800	31.625	8.05	7.34
45463.76			6.87	15.840	31.640	8.05	7.31
45464.51			6.96	15.847	31.639	8.04	7.25
45465.26	39.34517	-74.40683	7.01	15.842	31.648	8.05	7.16
45466.01			7.16	15.853	31.639	8.05	7.10
45466.76	39.34517	-74.40683	7.40	15.865	31.657	8.05	7.13
45467.51			7.71	15.895	31.661	8.05	7.30
45468.26			8.04	15.903	31.671	8.05	7.40
45469.01	39.34517	-74.40683	8.26	15.898	31.679	8.05	7.38
45469.76			8.41	15.915	31.670	8.05	7.36
45470.51	39.34517	-74.40667	8.62	15.917	31.666	8.05	7.40
45471.26			8.77	15.901	31.678	8.05	7.40
45472.01			8.97	15.908	31.666	8.05	7.35
45491.64	39.34517	-74.40700	8.99	15.912	31.657	8.05	7.33

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Brigantine Inlet OCTOBER 19 1994 Station B-7

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
47316.79	39.34383	-74.39783	0.15	15.788	31.599	8.02	7.05
47323.96	39.34400	-74.39783	0.26	15.789	31.594	8.02	7.03
47324.71			0.77	15.778	31.602	8.00	7.02
47325.46			1.06	15.786	31.603	8.00	7.04
47326.21	39.34400	-74.39783	1.37	15.771	31.595	8.00	7.03
47326.96			1.83	15.744	31.593	7.99	7.00
47327.71	39.34400	-74.39783	1.88	15.733	31.605	7.99	7.01
47328.46			2.06	15.727	31.596	7.99	7.05
47329.21			2.34	15.721	31.601	7.99	7.04
47329.96	39.34400	-74.39783	2.47	15.721	31.603	8.00	6.96
47330.71			2.65	15.716	31.600	8.00	6.97
47331.46			2.84	15.709	31.594	8.00	7.03
47332.21	39.34400	-74.39783	3.05	15.689	31.600	8.00	7.01
47332.96			3.31	15.659	31.610	8.00	6.98
47333.71	39.34400	-74.39783	3.57	15.643	31.611	8.00	7.01
47334.46			3.67	15.644	31.615	8.00	7.00
47335.21			3.80	15.644	31.612	8.00	6.99
47335.96	39.34400	-74.39783	3.93	15.655	31.605	8.00	6.99
47336.71			4.04	15.653	31.612	8.00	6.99
47337.46			4.29	15.636	31.611	8.00	6.98
47338.21	39.34400	-74.39783	4.38	15.633	31.619	8.00	6.94
47338.96			4.58	15.639	31.611	8.00	6.92
47339.71	39.34400	-74.39783	4.85	15.637	31.618	8.00	6.90
47340.46			5.07	15.632	31.622	8.00	6.82
47341.21			5.15	15.639	31.616	8.00	6.71
47341.96	39.34400	-74.39783	5.29	15.637	31.618	8.00	6.65
47342.71			5.26	15.632	31.619	8.00	6.63
47343.46	39.34400	-74.39783	5.42	15.632	31.624	8.00	6.61
47344.21			5.72	15.641	31.621	8.00	6.61
47344.96			5.84	15.634	31.623	8.00	6.63
47345.71	39.34400	-74.39783	5.87	15.646	31.612	8.01	6.65
47346.46			6.17	15.634	31.626	8.01	6.60
47347.21			6.41	15.643	31.619	8.01	6.54
47347.96	39.34400	-74.39783	6.30	15.648	31.617	8.01	6.52
47348.71			6.62	15.637	31.628	8.01	6.50
47349.46	39.34400	-74.39767	6.90	15.646	31.628	8.01	6.47
47350.21			6.79	15.641	31.625	8.01	6.48
47350.96			7.02	15.651	31.617	8.01	6.56
47351.71	39.34400	-74.39767	7.13	15.652	31.619	8.01	6.67
47352.46			6.95	15.648	31.620	8.02	6.73
47353.21			7.04	15.645	31.620	8.02	6.71
47363.71	39.34400	-74.39767	7.35	15.640	31.623	8.02	6.69

Brigantine Inlet OCTOBER 20 1994 Station B-8

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
46519.05	39.34700	-74.40916	0.16	16.211	31.629	8.07	6.51
46521.76			0.36	16.198	31.639	8.07	6.52
46522.25			0.72	16.203	31.636	8.06	6.52
46522.74			1.01	16.209	31.634	8.06	6.54
46523.23	39.34700	-74.40916	1.26	16.190	31.639	8.06	6.58
46523.73			1.48	16.148	31.648	8.06	6.59
46524.22			1.70	16.151	31.638	8.06	6.62
46524.71			1.85	16.116	31.655	8.06	6.62
46525.20	39.34700	-74.40916	2.16	16.066	31.640	8.06	6.59
46525.70			2.45	16.050	31.639	8.06	6.59
46526.19			2.54	16.031	31.651	8.06	6.61
46526.68			2.70	16.045	31.622	8.06	6.61
46527.17	39.34700	-74.40916	3.00	16.023	31.632	8.06	6.60
46527.66			3.27	16.001	31.639	8.06	6.57
46528.16			3.47	16.004	31.627	8.06	6.57
46528.65			3.36	16.031	31.616	8.06	6.58
46529.14	39.34683	-74.40900	3.30	16.012	31.627	8.06	6.59
46529.63			3.40	16.004	31.637	8.06	6.58
46530.13			3.69	16.009	31.625	8.06	6.60
46530.62			4.07	15.982	31.637	8.06	6.61
46531.11	39.34683	-74.40916	4.40	15.912	31.599	8.06	6.63
46531.60			4.70	15.879	31.621	8.05	6.64
46532.09			4.98	15.844	31.622	8.05	6.63
46532.59	39.34683	-74.40916	5.16	15.834	31.626	8.05	6.58
46533.08			5.32	15.825	31.619	8.05	6.54
46533.57			5.42	15.831	31.607	8.05	6.51
46534.06			5.60	15.806	31.617	8.06	6.49
46534.55	39.34683	-74.40916	5.84	15.793	31.606	8.05	6.48
46535.05			5.85	15.790	31.616	8.06	6.46
46535.54			5.69	15.793	31.625	8.05	6.45
46536.03			5.71	15.799	31.623	8.05	6.44
46536.52	39.34683	-74.40916	5.99	15.799	31.615	8.05	6.45
46537.02			6.39	15.771	31.613	8.05	6.46
46537.51			6.51	15.777	31.612	8.05	6.45
46538.00			6.43	15.779	31.621	8.05	6.41
46538.49	39.34683	-74.40916	6.43	15.782	31.615	8.05	6.35
46538.98			6.63	15.788	31.610	8.05	6.29
46539.48			6.79	15.782	31.611	8.05	6.26
46567.90	39.34700	-74.40900					

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Brigantine Inlet OCTOBER 20 1994 Station B-9

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
44124.50	39.34667	-74.40500	0.24	16.142	31.597	8.05	6.91
44126.63			0.62	16.139	31.597	8.04	6.88
44127.63	39.34667	-74.40500	0.91	16.124	31.609	8.04	6.89
44128.63			1.29	16.108	31.602	8.04	6.81
44129.63	39.34667	-74.40500	1.56	16.077	31.595	8.04	6.75
44130.63			1.61	16.077	31.597	8.04	6.72
44131.63	39.34667	-74.40500	1.75	16.070	31.600	8.04	6.62
44132.63			2.01	16.058	31.597	8.04	6.45
44133.63	39.34667	-74.40500	2.17	16.061	31.596	8.04	6.45
44134.63			2.25	16.058	31.602	8.04	6.69
44135.63	39.34667	-74.40517	2.29	16.066	31.595	8.04	6.88
44136.63			2.25	16.051	31.605	8.04	6.91
44137.63	39.34683	-74.40517	2.53	16.039	31.594	8.04	6.87
44138.63			2.66	16.036	31.596	8.04	6.80
44139.63	39.34683	-74.40517	2.83	16.017	31.598	8.04	6.64
44140.63			3.19	15.997	31.599	8.04	6.55
44141.63	39.34683	-74.40517	3.32	15.994	31.607	8.04	6.46
44142.63			3.36	15.998	31.602	8.04	6.37
44143.63	39.34683	-74.40517	3.54	15.994	31.600	8.04	6.39
44144.63			3.96	15.994	31.589	8.04	6.50
44145.63	39.34683	-74.40533	4.06	15.973	31.604	8.04	6.54
44146.63			4.43	15.924	31.585	8.04	6.61
44147.63	39.34683	-74.40533	4.74	15.839	31.605	8.04	6.58
44148.63			4.50	15.899	31.591	8.04	6.53
44149.63	39.34683	-74.40517	4.83	15.857	31.600	8.04	6.58
44150.63			5.22	15.818	31.608	8.04	6.68
44151.63	39.34683	-74.40517	5.45	15.816	31.608	8.04	6.66
44152.63	39.34683	-74.40517	5.78	15.810	31.609	8.04	6.63
44153.63			6.03	15.814	31.605	8.04	6.52
44154.63	39.34683	-74.40517	6.05	15.819	31.606	8.04	6.47
44155.63			6.07	15.823	31.605	8.04	6.45
44156.63	39.34683	-74.40517	6.42	15.812	31.611	8.04	6.41
44157.63			6.51	15.807	31.614	8.04	6.30
44158.63	39.34683	-74.40517	6.80	15.802	31.625	8.04	6.11
44159.63			7.02	15.831	31.609	8.04	5.96
44160.63	39.34683	-74.40517	7.09	15.808	31.625	8.04	5.93
44161.63			7.60	15.814	31.626	8.04	6.08
44170.75	39.34650	-74.40517	7.66	15.818	31.625	8.04	6.28

Brigantine Inlet OCTOBER 20 1994 Station B-10

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
53524.87	39.34617	-74.39684	0.19	15.911	31.501	8.06	6.98
53529.30	39.34617	-74.39667	0.23	15.903	31.513	8.06	6.96
53529.79			0.47	15.892	31.524	8.06	6.95
53530.28			0.62	15.892	31.519	8.06	6.96
53530.77			0.92	15.903	31.511	8.05	6.96
53531.27	39.34617	-74.39667	1.40	15.889	31.511	8.05	6.94
53531.76			1.79	15.884	31.504	8.05	6.91
53532.25			2.01	15.879	31.508	8.05	6.92
53532.74			2.19	15.871	31.515	8.05	6.93
53533.23	39.34617	-74.39667	2.48	15.876	31.508	8.06	6.95
53533.73			2.81	15.855	31.517	8.08	6.99
53534.22			3.16	15.882	31.498	8.09	7.01
53534.71	39.34617	-74.39667	3.26	15.873	31.502	8.11	7.02
53535.20			3.32	15.870	31.508	8.12	7.02
53535.70			3.64	15.878	31.505	8.12	7.03
53536.19			4.09	15.868	31.502	8.12	7.05
53536.68	39.34617	-74.39667	4.52	15.867	31.503	8.11	7.07
53537.17			4.44	15.868	31.502	8.11	7.10
53537.66			4.50	15.870	31.504	8.10	7.17
53538.16			4.88	15.873	31.502	8.10	7.24
53538.65	39.34617	-74.39667	5.12	15.865	31.505	8.10	7.29
53539.14			5.00	15.860	31.509	8.12	7.34
53539.63			4.85	15.862	31.508	8.14	7.38
53540.13			5.08	15.873	31.495	8.16	7.39
53540.62	39.34617	-74.39667	5.47	15.873	31.498	8.18	7.39
53541.11			5.70	15.854	31.509	8.22	7.40
53541.60			5.68	15.873	31.498	8.22	7.41
53542.09			5.73	15.868	31.499	8.21	7.43
53542.59	39.34617	-74.39667	6.12	15.870	31.496	8.20	7.46
53543.08			6.38	15.868	31.499	8.20	7.49
53543.57			6.50	15.868	31.498	8.19	7.51
53544.06			6.43	15.867	31.496	8.19	7.53
53544.55	39.34617	-74.39667	6.54	15.870	31.500	8.19	7.54
53545.05			6.59	15.868	31.498	8.19	7.57
53545.54			6.57	15.876	31.492	8.19	7.59
53546.03			6.57	15.876	31.492	8.20	7.62
53546.52	39.34617	-74.39667	6.58	15.870	31.496	8.20	7.63
53547.02			6.61	15.863	31.495	8.19	7.60
53558.59	39.34617	-74.39667	6.67	15.857	31.507	8.17	7.58

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Brigantine Inlet OCTOBER 20 1994 Station B-11

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
52412.63	39.34600	-74.39767	0.20	15.873	31.531	8.04	6.74
52416.56	39.34600	-74.39767	0.34	15.871	31.543	8.03	6.73
52417.05			0.64	15.881	31.532	8.03	6.72
52417.55			0.91	15.865	31.526	8.03	6.76
52418.04			1.25	15.854	31.525	8.02	6.80
52418.53	39.34600	-74.39750	1.52	15.846	31.531	8.03	6.81
52419.02			1.72	15.852	31.527	8.03	6.77
52419.52			1.89	15.843	31.530	8.03	6.71
52420.01			2.09	15.835	31.540	8.03	6.72
52420.50	39.34600	-74.39750	2.42	15.835	31.539	8.03	6.77
52420.99			2.72	15.836	31.539	8.03	6.80
52421.48			2.93	15.832	31.549	8.03	6.80
52421.98			3.01	15.847	31.533	8.03	6.78
52422.47	39.34600	-74.39767	3.10	15.844	31.532	8.03	6.77
52422.96			3.32	15.839	31.543	8.03	6.73
52423.45			3.64	15.846	31.541	8.03	6.65
52423.95			3.97	15.857	31.522	8.03	6.62
52424.44	39.34600	-74.39767	4.26	15.833	31.548	8.03	6.61
52424.93			4.51	15.855	31.523	8.03	6.59
52425.42			4.78	15.852	31.532	8.03	6.63
52425.91			5.07	15.841	31.542	8.03	6.73
52426.41	39.34600	-74.39767	5.24	15.846	31.530	8.02	6.85
52426.90			5.34	15.849	31.534	8.02	6.92
52427.39			5.53	15.835	31.542	8.03	6.94
52427.88			5.65	15.849	31.534	8.03	6.94
52428.38	39.34600	-74.39767	5.78	15.849	31.531	8.03	6.98
52428.87			5.84	15.841	31.544	8.03	6.99
52429.36			5.97	15.852	31.535	8.02	7.00
52429.85			6.18	15.852	31.535	8.03	6.99
52430.34	39.34600	-74.39767	6.36	15.852	31.532	8.03	6.97
52430.84			6.52	15.849	31.530	8.03	6.94
52453.11	39.34583	-74.39750					

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Brigantine Inlet OCTOBER 20 1994 Station B-12

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
51044.01	39.34450	-74.39584	0.30	15.835	31.541	8.03	6.88
51048.07			0.32	15.841	31.529	8.03	6.88
51048.56	39.34450	-74.39584	0.46	15.851	31.525	8.03	6.87
51049.05			0.75	15.855	31.528	8.03	6.83
51049.55			1.06	15.830	31.538	8.03	6.78
51050.04			1.36	15.819	31.536	8.03	6.79
51050.53	39.34450	-74.39584	1.56	15.825	31.530	8.03	6.81
51051.02			1.87	15.819	31.542	8.03	6.81
51051.52			2.14	15.811	31.531	8.03	6.80
51052.01			2.47	15.808	31.534	8.03	6.77
51052.50	39.34450	-74.39584	2.72	15.795	31.545	8.03	6.78
51052.99			2.96	15.795	31.547	8.03	6.84
51053.48			3.16	15.797	31.542	8.03	6.89
51053.98			3.40	15.795	31.548	8.03	6.91
51054.47	39.34450	-74.39567	3.59	15.800	31.536	8.03	6.90
51054.96			3.73	15.779	31.552	8.03	6.89
51055.45			3.94	15.784	31.538	8.03	6.89
51055.95			4.18	15.776	31.544	8.03	6.89
51056.44	39.34450	-74.39567	4.25	15.773	31.540	8.03	6.86
51056.93			4.37	15.765	31.550	8.03	6.82
51057.42			4.59	15.765	31.546	8.03	6.84
51057.91			4.82	15.757	31.555	8.03	6.86
51058.41	39.34450	-74.39567	5.06	15.763	31.551	8.03	6.85
51058.90			5.24	15.763	31.545	8.03	6.82
51059.39			5.46	15.755	31.558	8.03	6.83
51059.88			5.67	15.749	31.563	8.03	6.85
51060.38	39.34450	-74.39567	5.71	15.757	31.555	8.03	6.85
51060.87			5.67	15.752	31.556	8.03	6.82
51061.36			5.74	15.763	31.547	8.03	6.78
51061.85			5.92	15.752	31.556	8.03	6.75
51062.34	39.34450	-74.39567	6.05	15.741	31.557	8.03	6.71
51062.84			6.17	15.725	31.570	8.03	6.69
51063.33			6.21	15.741	31.554	8.03	6.68
51063.82			6.20	15.725	31.557	8.03	6.67
51064.31	39.34450	-74.39567	6.21	15.728	31.555	8.03	6.64
51064.80			6.20	15.728	31.562	8.03	6.64
51065.30			6.15	15.736	31.562	8.03	6.64
51065.79			6.20	15.744	31.559	8.03	6.64
51066.28	39.34450	-74.39567	6.30	15.734	31.559	8.03	6.61
51066.77			6.55	15.728	31.564	8.02	6.57
51078.10	39.34450	-74.39584	6.74	15.749	31.545	8.03	6.55

Brigantine Inlet OCTOBER 19 1994 Station B-13

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
49804.01	39.34483	-74.39950	0.11	15.642	31.562	8.02	6.74
49807.68	39.34483	-74.39950	0.39	15.637	31.566	8.02	6.73
49808.43			0.68	15.634	31.573	8.01	6.80
49809.18			0.87	15.637	31.566	8.01	6.84
49809.93	39.34483	-74.39950	1.21	15.630	31.569	8.01	6.86
49810.68			1.48	15.628	31.567	8.01	6.91
49811.43			1.68	15.639	31.564	8.01	6.98
49812.18	39.34483	-74.39950	1.92	15.610	31.584	8.01	7.11
49812.93			2.01	15.623	31.572	8.01	7.14
49813.68	39.34483	-74.39950	1.97	15.626	31.569	8.01	7.16
49814.43			2.27	15.628	31.562	8.01	7.15
49815.18			2.54	15.621	31.571	8.01	7.09
49815.93	39.34483	-74.39950	2.59	15.620	31.574	8.01	7.05
49816.68			2.84	15.621	31.564	8.02	7.06
49817.43	39.34483	-74.39950	3.16	15.612	31.571	8.02	7.07
49818.18			3.43	15.602	31.576	8.02	7.01
49818.93			3.69	15.596	31.579	8.03	6.92
49819.68	39.34483	-74.39933	3.76	15.596	31.574	8.02	6.83
49820.43			3.92	15.596	31.578	8.03	6.71
49821.18	39.34483	-74.39933	4.10	15.598	31.577	8.02	6.55
49821.93			4.08	15.591	31.583	8.02	6.42
49822.68			4.31	15.580	31.586	8.02	6.31
49823.43	39.34483	-74.39933	4.65	15.554	31.607	8.02	6.20
49824.18			4.83	15.564	31.606	8.02	6.16
49824.93	39.34483	-74.39933	5.08	15.570	31.609	8.02	6.19
49825.68			5.23	15.564	31.608	8.02	6.23
49826.43			5.28	15.563	31.607	8.02	6.36
49827.18	39.34483	-74.39933	5.53	15.566	31.612	8.02	6.44
49827.93			5.75	15.569	31.607	8.02	6.48
49828.68			5.71	15.570	31.606	8.02	6.55
49829.43	39.34483	-74.39933	5.99	15.564	31.615	8.02	6.58
49830.18			6.28	15.575	31.606	8.02	6.60
49830.93	39.34483	-74.39933	6.26	15.572	31.611	8.02	6.60
49831.68			6.38	15.571	31.607	8.02	6.52
49832.43			6.36	15.561	31.617	8.02	6.47
49833.18	39.34483	-74.39933	6.28	15.575	31.606	8.02	6.49
49833.93			6.19	15.571	31.611	8.02	6.50
49834.68			6.10	15.572	31.609	8.02	6.53
49835.43	39.34483	-74.39933	6.08	15.568	31.608	8.02	6.61
49836.18			6.12	15.571	31.609	8.03	6.62
49836.93	39.34483	-74.39933	6.24	15.582	31.596	8.02	6.61
49837.68			6.41	15.579	31.591	8.03	6.64
49845.09	39.34483	-74.39933	6.52	15.573	31.593	8.03	6.60

Brigantine Inlet OCTOBER 20 1994 Station B-14

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
47981.94	39.34566	-74.40266	0.40	16.108	31.614	8.05	6.73
47984.15			0.47	16.107	31.614	8.05	6.75
47984.64			0.74	16.102	31.623	8.05	6.75
47985.13	39.34566	-74.40266	1.04	16.110	31.615	8.05	6.75
47985.63			1.17	16.102	31.626	8.05	6.78
47986.12			1.41	16.116	31.604	8.04	6.78
47986.61			1.65	16.096	31.616	8.04	6.76
47987.10	39.34566	-74.40266	1.66	16.097	31.615	8.05	6.71
47987.59			1.73	16.113	31.603	8.05	6.66
47988.09			2.00	16.075	31.595	8.05	6.66
47988.58			2.23	16.061	31.605	8.04	6.71
47989.07	39.34566	-74.40266	2.40	16.053	31.601	8.04	6.75
47989.56			2.49	16.026	31.616	8.05	6.78
47990.05			2.76	16.031	31.588	8.05	6.83
47990.55			2.99	16.018	31.602	8.05	6.89
47991.04	39.34566	-74.40266	3.13	15.982	31.586	8.05	6.93
47991.53			3.23	16.004	31.578	8.05	6.96
47992.02			3.45	15.980	31.593	8.05	6.97
47992.52			3.69	15.947	31.598	8.05	6.95
47993.01	39.34566	-74.40266	3.91	15.955	31.586	8.05	6.94
47993.50			3.91	15.963	31.589	8.05	6.96
47993.99			4.08	15.961	31.584	8.04	6.96
47994.48	39.34566	-74.40266	4.34	15.912	31.553	8.04	6.97
47994.98			4.47	15.833	31.602	8.04	7.00
47995.47			4.55	15.858	31.569	8.04	7.04
47995.96			4.84	15.820	31.578	8.04	7.08
47996.45	39.34550	-74.40266	5.15	15.801	31.596	8.04	7.09
47996.95			5.40	15.806	31.610	8.04	7.06
47997.44			5.45	15.812	31.598	8.04	7.04
47997.93			5.66	15.809	31.607	8.04	7.03
47998.42	39.34550	-74.40266	5.96	15.806	31.613	8.04	7.03
47998.91			6.11	15.817	31.607	8.04	7.02
47999.41			6.08	15.814	31.603	8.04	6.98
47999.90			6.20	15.809	31.620	8.04	6.95
48000.39	39.34550	-74.40266	6.53	15.825	31.622	8.04	6.93
48000.88			6.78	15.825	31.633	8.04	6.87
48001.38			6.93	15.830	31.628	8.04	6.84
48001.87			7.10	15.836	31.626	8.04	6.84
48002.36	39.34550	-74.40266	7.32	15.825	31.639	8.04	6.84
48002.85			7.53	15.833	31.633	8.04	6.83
48003.34			7.66	15.836	31.631	8.04	6.82
48003.84			7.79	15.844	31.627	8.04	6.83
48004.33	39.34550	-74.40266	7.79	15.844	31.628	8.04	6.84
48004.82			7.76	15.836	31.626	8.04	6.85
48005.31			7.97	15.836	31.633	8.04	6.85
48005.80			8.06	15.839	31.628	8.04	6.83
48006.30	39.34550	-74.40266	8.15	15.846	31.623	8.04	6.82
48037.18	39.34566	-74.40234					

Brigantine Inlet OCTOBER 19 1994 Station R-1

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
36984.59	39.35867	-74.39616	0.53	15.203	31.542	8.00	7.01
36994.09	39.35850	-74.39633	0.58	15.206	31.543	8.00	6.97
36994.59			0.69	15.203	31.545	7.98	6.94
36995.09			0.81	15.188	31.561	7.98	6.95
36995.59			0.96	15.193	31.561	7.97	6.98
36996.09	39.35850	-74.39633	1.07	15.188	31.558	7.96	7.00
36996.59			1.15	15.180	31.557	7.96	7.03
36997.09			1.26	15.172	31.563	7.96	7.06
36997.59			1.46	15.172	31.556	7.96	7.06
36998.09	39.35850	-74.39633	1.70	15.172	31.564	7.96	7.01
36998.59			1.94	15.172	31.556	7.97	6.97
36999.09			2.11	15.172	31.553	7.97	7.00
36999.59	39.35850	-74.39633	2.22	15.164	31.554	7.97	7.03
37000.09			2.40	15.167	31.549	7.98	7.08
37000.59			2.56	15.164	31.551	7.99	7.10
37001.09			2.65	15.164	31.551	8.00	7.11
37001.59	39.35850	-74.39633	2.69	15.159	31.548	8.00	7.07
37002.09			2.76	15.172	31.541	8.01	7.04
37002.59			2.87	15.167	31.542	8.01	7.02
37003.09			2.89	15.164	31.548	8.00	7.04
37003.59	39.35850	-74.39616	2.88	15.156	31.554	7.98	7.06
37004.09			2.93	15.161	31.547	7.98	7.07
37004.59			3.06	15.167	31.545	7.98	7.07
37005.09			3.24	15.162	31.549	7.98	7.05
37005.59	39.35850	-74.39616	3.30	15.167	31.546	7.98	7.05
37006.09			3.29	15.174	31.540	7.98	7.06
37006.59			3.29	15.167	31.545	7.99	7.05
37007.09			3.36	15.164	31.548	7.99	7.05
37007.59	39.35833	-74.39616	3.40	15.162	31.553	7.99	7.07
37008.09			3.43	15.159	31.552	8.00	7.07
37008.59			3.70	15.161	31.543	8.01	7.02
37009.09			4.03	15.164	31.545	8.02	6.97
37009.59	39.35833	-74.39616	4.13	15.159	31.541	8.02	6.98
37010.09			4.11	15.151	31.550	8.03	7.03
37010.59			4.07	15.154	31.542	8.04	7.07
37011.09			4.15	15.154	31.545	8.05	7.11
37011.59	39.35833	-74.39616	4.24	15.156	31.543	8.07	7.14
37012.09			4.32	15.148	31.549	8.09	7.15
37012.59			4.44	15.146	31.548	8.10	7.15
37013.09			4.66	15.151	31.539	8.10	7.13
37013.59	39.35833	-74.39616	4.79	15.148	31.532	8.09	7.12
37014.09			4.83	15.154	31.499	8.09	7.12
37031.71	39.35833	-74.39616					

Brigantine Inlet OCTOBER 20 1994 Station R-2

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
34707.73	39.36600	-74.39433	0.28	15.707	31.552	8.06	7.01
34712.65			0.46	15.709	31.554	8.06	7.02
34713.14	39.36600	-74.39433	0.77	15.704	31.547	8.05	6.99
34713.63			0.99	15.671	31.556	8.05	6.97
34714.13			1.08	15.672	31.551	8.05	6.98
34714.62			1.23	15.671	31.553	8.05	6.99
34715.11	39.36600	-74.39433	1.40	15.667	31.559	8.05	6.96
34715.60			1.71	15.643	31.547	8.05	6.93
34716.09			1.89	15.629	31.554	8.05	6.95
34716.59			1.82	15.624	31.569	8.05	6.99
34717.08	39.36600	-74.39433	1.84	15.637	31.555	8.05	6.98
34717.57			2.12	15.629	31.554	8.04	6.94
34718.06			2.44	15.621	31.557	8.04	6.94
34718.55			2.65	15.624	31.555	8.05	6.95
34719.05	39.36600	-74.39433	2.82	15.629	31.551	8.05	6.98
34719.54			2.89	15.616	31.564	8.05	7.02
34720.03			2.96	15.611	31.561	8.05	7.04
34720.52			3.13	15.618	31.552	8.04	7.05
34721.02	39.36600	-74.39433	3.40	15.605	31.562	8.05	7.09
34721.51			3.73	15.610	31.559	8.04	7.11
34722.00			3.94	15.592	31.562	8.04	7.06
34722.49			4.07	15.602	31.554	8.04	7.00
34722.98	39.36600	-74.39433	4.09	15.594	31.563	8.04	6.99
34723.48			4.15	15.594	31.561	8.04	7.01
34723.97			4.29	15.600	31.559	8.04	7.01
34724.46			4.55	15.592	31.562	8.05	7.01
34724.95	39.36600	-74.39433	4.77	15.600	31.549	8.04	7.00
34725.45			4.92	15.597	31.565	8.05	6.96
34725.94			5.01	15.581	31.564	8.04	6.93
34726.43			5.26	15.589	31.557	8.04	6.91
34726.92	39.36600	-74.39433	5.57	15.591	31.555	8.04	6.91
34727.41			5.64	15.594	31.556	8.04	6.92
34727.91			5.67	15.581	31.567	8.04	6.93
34728.40			5.69	15.583	31.562	8.04	6.89
34728.89	39.36600	-74.39417	5.74	15.592	31.551	8.04	6.83
34729.38			5.75	15.578	31.562	8.04	6.78
34748.70	39.36600	-74.39417					

Brigantine Inlet   OCTOBER 20 1994   Station R-3

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
35559.94	39.36400	-74.39283	0.27	15.712	31.562	8.04	6.97
35562.77			0.48	15.725	31.559	8.04	6.98
35563.27	39.36400	-74.39283	0.91	15.728	31.545	8.04	6.99
35563.76			1.30	15.680	31.541	8.03	6.96
35564.25			1.67	15.642	31.559	8.03	6.95
35564.74			1.72	15.653	31.542	8.03	6.97
35565.23	39.36400	-74.39283	1.79	15.643	31.554	8.03	6.99
35565.73			1.99	15.650	31.541	8.03	6.99
35566.22			2.15	15.624	31.554	8.03	7.01
35566.71			2.32	15.626	31.556	8.03	7.00
35567.20	39.36400	-74.39283	2.53	15.618	31.556	8.03	6.97
35567.70			2.82	15.616	31.558	8.03	6.95
35568.19			3.10	15.613	31.561	8.03	6.95
35568.68			3.14	15.608	31.557	8.03	6.99
35569.17	39.36383	-74.39283	3.09	15.607	31.561	8.03	7.01
35569.66			3.09	15.613	31.553	8.03	7.01
35570.16			3.18	15.602	31.561	8.03	6.98
35570.65			3.27	15.608	31.564	8.03	6.95
35571.14	39.36383	-74.39283	3.29	15.605	31.559	8.03	6.96
35571.63			3.34	15.608	31.556	8.03	6.99
35572.13			3.51	15.602	31.562	8.03	7.00
35572.62			3.72	15.602	31.561	8.03	7.02
35573.11	39.36383	-74.39283	3.93	15.597	31.565	8.03	7.05
35573.60			4.13	15.597	31.562	8.03	7.04
355-74.09			4.25	15.597	31.561	8.03	7.02
355-74.59			4.38	15.608	31.559	8.03	6.99
35575.08	39.36383	-74.39283	4.65	15.602	31.554	8.03	6.97
35575.57			4.93	15.589	31.568	8.03	6.97
35576.06			5.23	15.602	31.557	8.03	7.00
35576.55			5.56	15.597	31.558	8.03	7.02
35577.05	39.36383	-74.39283	5.88	15.589	31.564	8.03	7.03
35577.54			5.97	15.592	31.561	8.03	7.04
35578.03			5.95	15.592	31.562	8.03	7.06
35578.52			5.95	15.589	31.561	8.03	7.09
35579.02	39.36383	-74.39283	6.11	15.592	31.561	8.03	7.12
35579.51			6.38	15.592	31.562	8.03	7.12
35603.75	39.36383	-74.39300					

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Brigantine Inlet   OCTOBER 20 1994   Station R-4

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
24937.41	39.36067	-74.40000	0.25	15.578	31.537	8.12	6.98
24943.98	39.36083	-74.40000	0.28	15.564	31.552	8.10	6.98
24944.48			0.39	15.569	31.555	8.09	6.95
24944.98			0.70	15.569	31.551	8.09	6.91
24945.47			1.03	15.559	31.567	8.09	6.84
24945.97	39.36083	-74.40017	1.32	15.564	31.559	8.08	6.82
24946.46			1.62	15.572	31.552	8.08	6.87
24946.96			1.76	15.566	31.554	8.08	6.93
24947.46			1.93	15.570	31.550	8.08	6.92
24947.95	39.36083	-74.40000	2.22	15.572	31.555	8.08	6.89
24948.45			2.50	15.577	31.551	8.08	6.87
24948.95			2.61	15.564	31.554	8.08	6.92
24949.44			2.75	15.575	31.550	8.08	7.00
24949.94	39.36067	-74.40000	2.98	15.570	31.557	8.07	7.07
24950.43			3.28	15.561	31.557	8.07	7.11
24950.93			3.49	15.567	31.555	8.07	7.13
24951.43	39.36067	-74.40000	3.64	15.572	31.555	8.06	7.13
24951.92			3.78	15.567	31.560	8.06	7.13
24952.42			3.83	15.569	31.557	8.06	7.11
24952.91			3.83	15.572	31.551	8.06	7.10
24953.41	39.36067	-74.40000	4.00	15.564	31.561	8.06	7.09
24953.91			4.26	15.567	31.559	8.06	7.09
24954.40			4.54	15.580	31.548	8.06	7.09
24954.90			4.69	15.575	31.556	8.06	7.07
24955.39	39.36067	-74.40000	4.77	15.565	31.560	8.06	7.07
24955.89			5.02	15.573	31.554	8.06	7.07
24956.39			5.37	15.569	31.557	8.06	7.06
24956.88			5.57	15.572	31.554	8.07	7.05
24957.38	39.36067	-74.40000	5.56	15.572	31.554	8.06	7.01
24957.88			5.61	15.575	31.559	8.07	6.95
24958.37			5.84	15.569	31.553	8.06	6.92
24958.87			6.05	15.570	31.556	8.06	6.92
24959.36	39.36067	-74.40000	6.25	15.569	31.560	8.06	6.91
24959.86			6.40	15.580	31.544	8.07	6.91
24960.36			6.63	15.569	31.556	8.08	6.93
24960.85			6.93	15.551	31.574	8.07	6.96
24981.07	39.36067	-74.40000	7.02	15.556	31.573	8.07	6.98

Brigantine Inlet OCTOBER 19 1994 Station R-5

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
54240.96	39.37650	-74.41317	0.35	15.656	31.358	8.06	9.65
54243.55			0.71	15.626	31.396	8.07	9.58
54244.80	39.37650	-74.41317	1.02	15.602	31.385	8.07	9.53
54246.05	39.37650	-74.41317	1.38	15.574	31.381	8.07	8.82
54247.30			1.98	15.612	31.391	8.08	8.05
54248.55	39.37650	-74.41317	2.27	15.586	31.404	8.08	7.89
54249.80	39.37650	-74.41317	2.65	15.592	31.387	8.08	7.78
54251.05			2.84	15.593	31.388	8.08	7.78
54252.30	39.37650	-74.41317	3.21	15.550	31.377	8.09	7.79
54253.55	39.37650	-74.41317	3.82	15.619	31.412	8.09	7.80
54254.80			4.08	15.619	31.409	8.09	7.75
54256.05	39.37650	-74.41317	4.61	15.625	31.406	8.09	7.72
54257.30			4.92	15.631	31.410	8.09	7.66
54258.55	39.37650	-74.41317	5.46	15.643	31.400	8.09	7.75
54259.80	39.37650	-74.41317	5.76	15.634	31.411	8.09	7.81
54261.05			6.38	15.635	31.402	8.09	7.75
54262.30	39.37650	-74.41317	6.81	15.632	31.413	8.09	7.76
54263.55	39.37650	-74.41317	6.79	15.637	31.403	8.09	7.74
54264.80			6.95	15.639	31.407	8.09	7.69
54266.05	39.37650	-74.41317	7.26	15.656	31.405	8.09	7.58
54267.30			7.81	15.668	31.422	8.09	7.55
54268.55	39.37650	-74.41317	8.11	15.671	31.421	8.09	7.52
54269.80	39.37650	-74.41317	8.59	15.666	31.423	8.09	7.46
54271.05			8.86	15.668	31.422	8.09	7.51
54272.30	39.37650	-74.41317	9.19	15.678	31.423	8.09	7.57
54273.55	39.37650	-74.41317	9.29	15.683	31.422	8.09	7.62
542-74.80			9.59	15.681	31.434	8.09	7.58
54276.05	39.37650	-74.41317	9.83	15.689	31.429	8.09	7.55
54277.30	39.37650	-74.41317	10.23	15.686	31.434	8.09	7.62
54278.55			10.51	15.679	31.440	8.09	7.61
54279.80	39.37650	-74.41317	10.78	15.686	31.438	8.09	7.57
54281.05			11.03	15.690	31.437	8.09	7.58
54282.30	39.37650	-74.41317	11.48	15.698	31.433	8.09	7.67
54283.55	39.37650	-74.41317	11.77	15.686	31.448	8.09	7.65
54284.80			11.80	15.693	31.444	8.09	7.61
54286.05	39.37650	-74.41317	11.63	15.689	31.448	8.09	7.49
54287.30	39.37650	-74.41317	11.48	15.699	31.437	8.09	7.37
54288.55			11.54	15.687	31.444	8.09	7.33
54289.80	39.37650	-74.41317	11.67	15.698	31.441	8.09	7.36
54291.05	39.37650	-74.41317	11.72	15.689	31.442	8.09	7.32
54306.47	39.37650	-74.41317	12.02	15.690	31.443	8.09	7.38

Brigantine Inlet OCTOBER 20 1994 Station R-6

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
40550.70	39.34883	-74.39516	0.24	15.767	31.552	8.02	6.75
40553.16	39.34900	-74.39516	0.26	15.764	31.561	8.02	6.77
40553.66			0.44	15.775	31.554	8.02	6.77
40554.15			0.78	15.759	31.557	8.01	6.79
40554.64			0.98	15.767	31.551	8.01	6.80
40555.13	39.34883	-74.39516	1.22	15.756	31.556	8.01	6.79
40555.63			1.63	15.748	31.566	8.02	6.73
40556.12			1.85	15.743	31.566	8.02	6.69
40556.61			1.95	15.756	31.552	8.02	6.68
40557.10	39.34883	-74.39516	2.15	15.751	31.564	8.02	6.67
40557.59			2.42	15.745	31.564	8.02	6.68
40558.09			2.73	15.748	31.559	8.02	6.74
40558.58			2.99	15.751	31.566	8.02	6.79
40559.07	39.34883	-74.39516	3.17	15.756	31.558	8.02	6.82
40559.56			3.29	15.753	31.564	8.02	6.83
40560.05			3.40	15.759	31.560	8.02	6.77
40560.55			3.61	15.746	31.571	8.02	6.71
40561.04	39.34883	-74.39516	3.84	15.740	31.581	8.02	6.73
40561.53			4.07	15.743	31.576	8.03	6.75
40562.02			4.25	15.750	31.577	8.03	6.72
40562.52			4.43	15.748	31.579	8.03	6.70
40563.01	39.34883	-74.39516	4.64	15.764	31.577	8.03	6.73
40563.50			4.82	15.767	31.571	8.03	6.78
40563.99			5.05	15.770	31.575	8.03	6.81
40564.48			5.43	15.775	31.582	8.03	6.78
40564.98	39.34883	-74.39516	5.63	15.769	31.583	8.03	6.66
40565.47			5.61	15.783	31.582	8.03	6.55
40565.96			5.58	15.775	31.591	8.04	6.54
40566.45			5.73	15.788	31.585	8.03	6.57
40566.95	39.34883	-74.39516	5.96	15.805	31.589	8.04	6.59
40567.44			6.11	15.794	31.594	8.03	6.62
40567.93			6.18	15.802	31.584	8.04	6.64
40568.43			6.36	15.802	31.594	8.04	6.64
40568.91	39.34900	-74.39516	6.58	15.791	31.600	8.04	6.64
40569.41			6.87	15.807	31.590	8.04	6.65
40569.90			7.09	15.804	31.592	8.05	6.69
40570.39			7.19	15.799	31.603	8.05	6.68
40570.88	39.34900	-74.39500	7.23	15.802	31.595	8.04	6.62
40571.38			7.38	15.802	31.598	8.04	6.56
40571.87			7.63	15.802	31.594	8.05	6.52
40572.36			7.88	15.799	31.599	8.05	6.49
40572.85	39.34883	-74.39500	8.18	15.805	31.595	8.05	6.49
40573.34			8.50	15.799	31.596	8.05	6.50
40573.84			8.76	15.799	31.592	8.05	6.51
405-74.33			8.94	15.802	31.597	8.05	6.52
405-74.82	39.34883	-74.39484	9.03	15.805	31.591	8.05	6.50
40575.31			9.13	15.796	31.598	8.04	6.47
40590.69	39.34900	-74.39516	9.18	15.815	31.586	8.04	6.44

Brigantine Inlet OCTOBER 20 1994 Station R-6

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L

Brigantine Inlet OCTOBER 19 1994 Station R-7

Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
48416.28	39.34383	-74.40000	0.16	15.725	31.572	8.00	6.97
48420.19	39.34383	-74.39983	0.19	15.719	31.579	8.01	6.94
48420.94			0.37	15.716	31.579	8.00	7.01
48421.69			0.80	15.724	31.576	8.00	7.05
48422.44	39.34383	-74.39983	1.18	15.716	31.582	8.00	7.02
48423.19			1.48	15.703	31.585	7.99	7.00
48423.94	39.34383	-74.39983	1.86	15.687	31.588	7.99	7.04
48424.69			2.29	15.673	31.583	7.99	7.09
48425.44			2.31	15.660	31.598	7.99	7.09
48426.19	39.34383	-74.39983	2.39	15.662	31.594	7.99	7.09
48426.94			2.75	15.647	31.601	8.00	7.02
48427.69	39.34383	-74.39983	2.96	15.651	31.598	8.00	7.05
48428.44			3.19	15.641	31.594	8.00	7.10
48429.19			3.28	15.648	31.591	8.00	7.08
48429.94	39.34383	-74.39983	3.27	15.643	31.595	8.01	7.07
48430.69			3.41	15.648	31.590	8.01	7.03
48431.44			3.73	15.613	31.605	8.02	6.95
48432.19	39.34383	-74.39983	3.82	15.600	31.613	8.01	6.84
48432.94			3.88	15.609	31.615	8.01	6.80
48433.69	39.34383	-74.39983	3.97	15.621	31.605	8.01	6.79
48434.44			3.88	15.602	31.621	8.02	6.72
48435.19			3.84	15.619	31.602	8.02	6.58
48435.94	39.34383	-74.39983	4.04	15.598	31.624	8.02	6.50
48436.69			3.94	15.617	31.606	8.02	6.53
48437.44			4.22	15.607	31.617	8.02	6.60
48438.19	39.34383	-74.39983	4.62	15.607	31.612	8.02	6.63
48438.94			4.80	15.610	31.614	8.02	6.61
48439.69	39.34383	-74.39983	5.09	15.614	31.610	8.02	6.64
48440.44			5.30	15.608	31.615	8.02	6.71
48441.19			5.47	15.598	31.623	8.02	6.70
48441.94	39.34383	-74.39983	5.67	15.612	31.614	8.01	6.74
48442.69			5.97	15.610	31.621	8.02	6.83
48443.44			6.19	15.613	31.621	8.02	6.91
48444.19	39.34383	-74.39983	6.35	15.621	31.611	8.02	6.92
48444.94			6.53	15.621	31.614	8.02	6.87
48473.19	39.34383	-74.39983					

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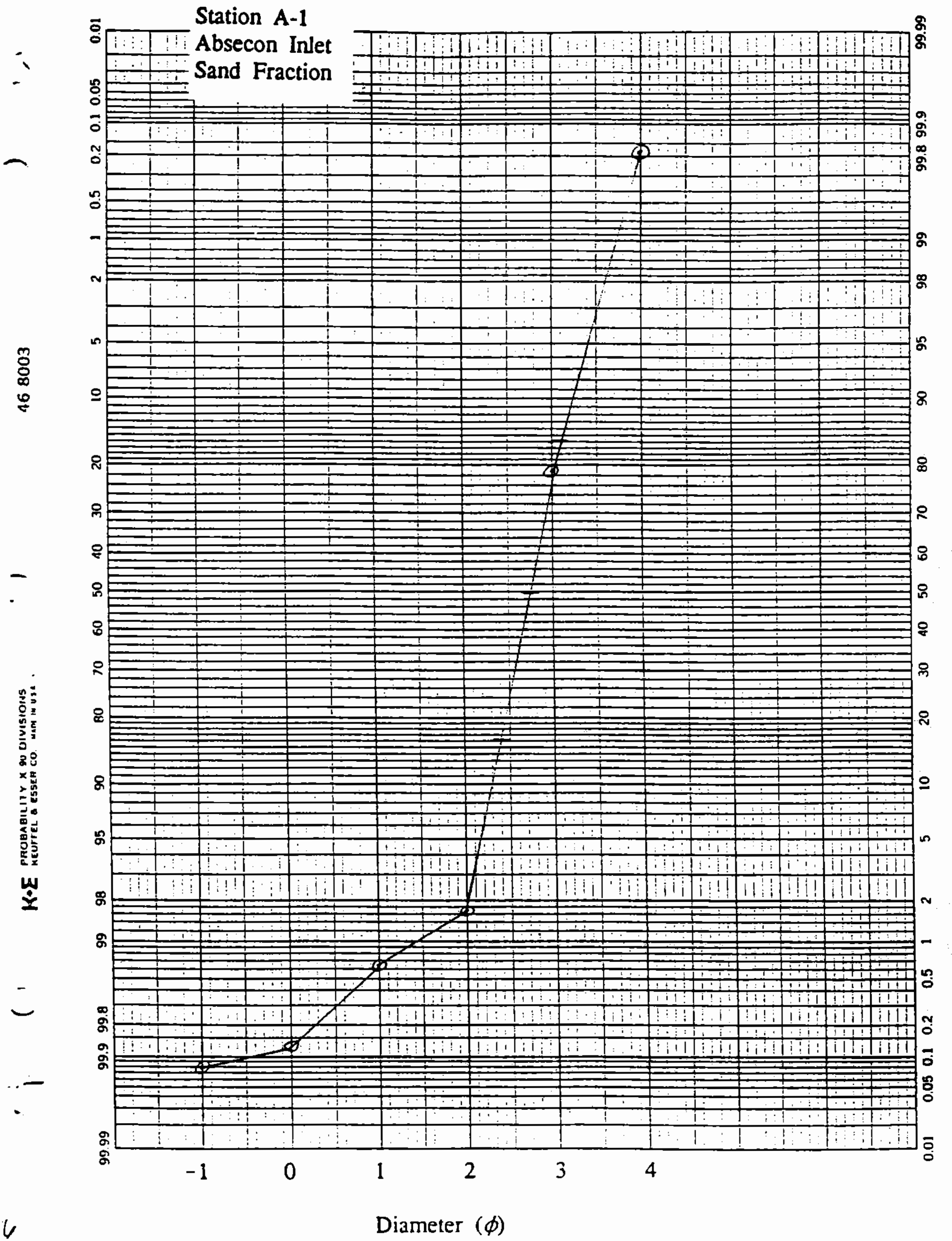
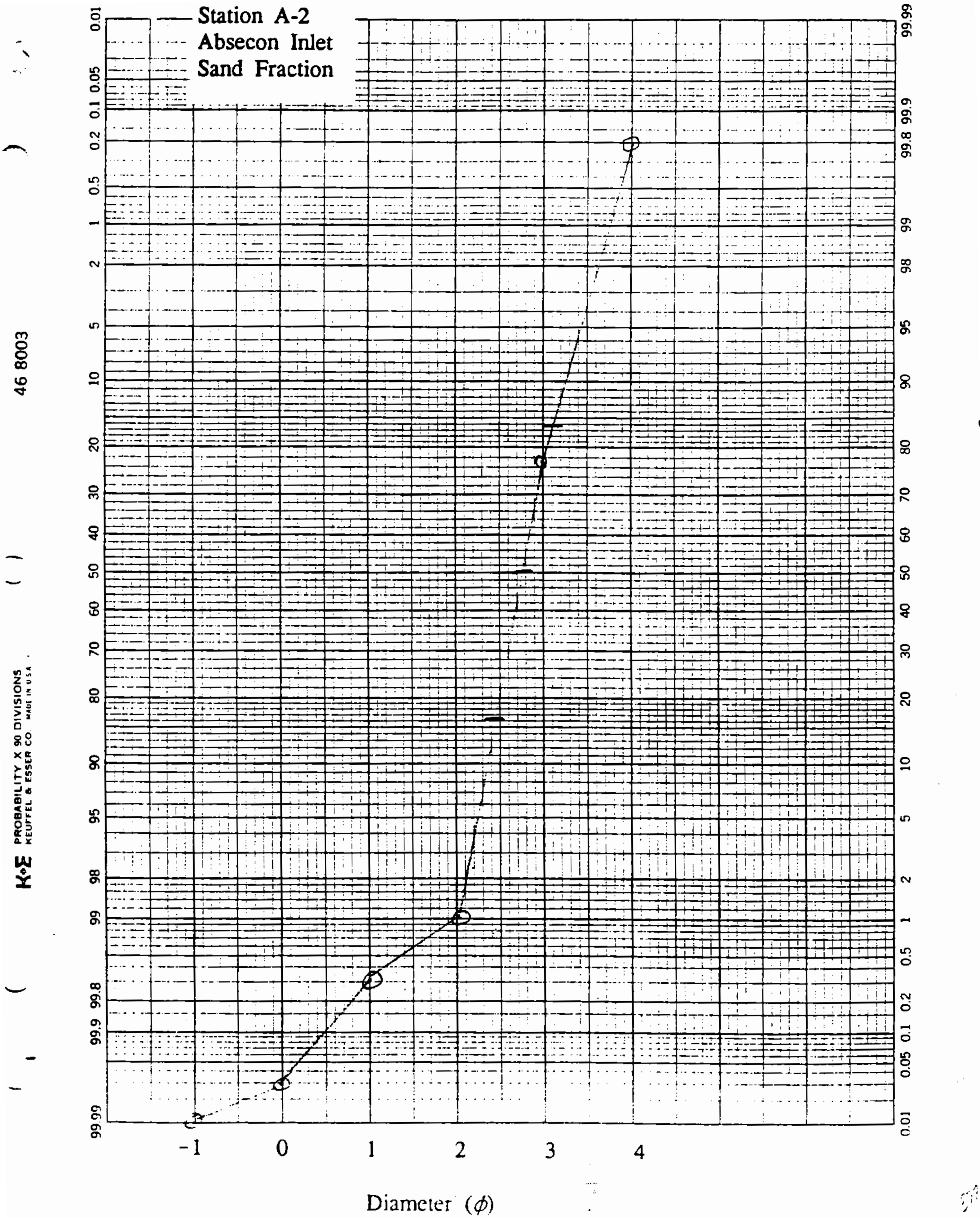
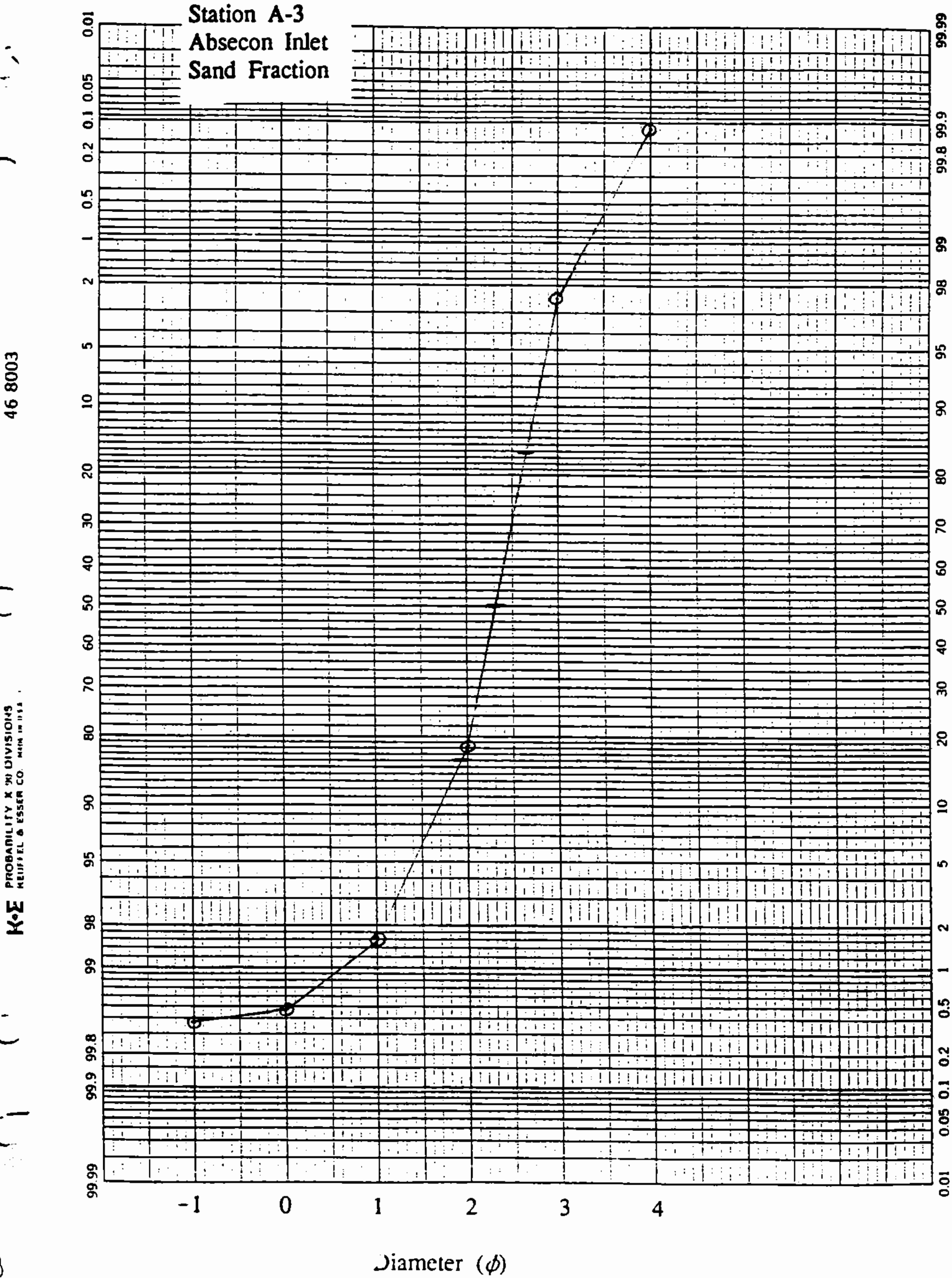
Brigantine Inlet OCTOBER 20 1994 Station R-8

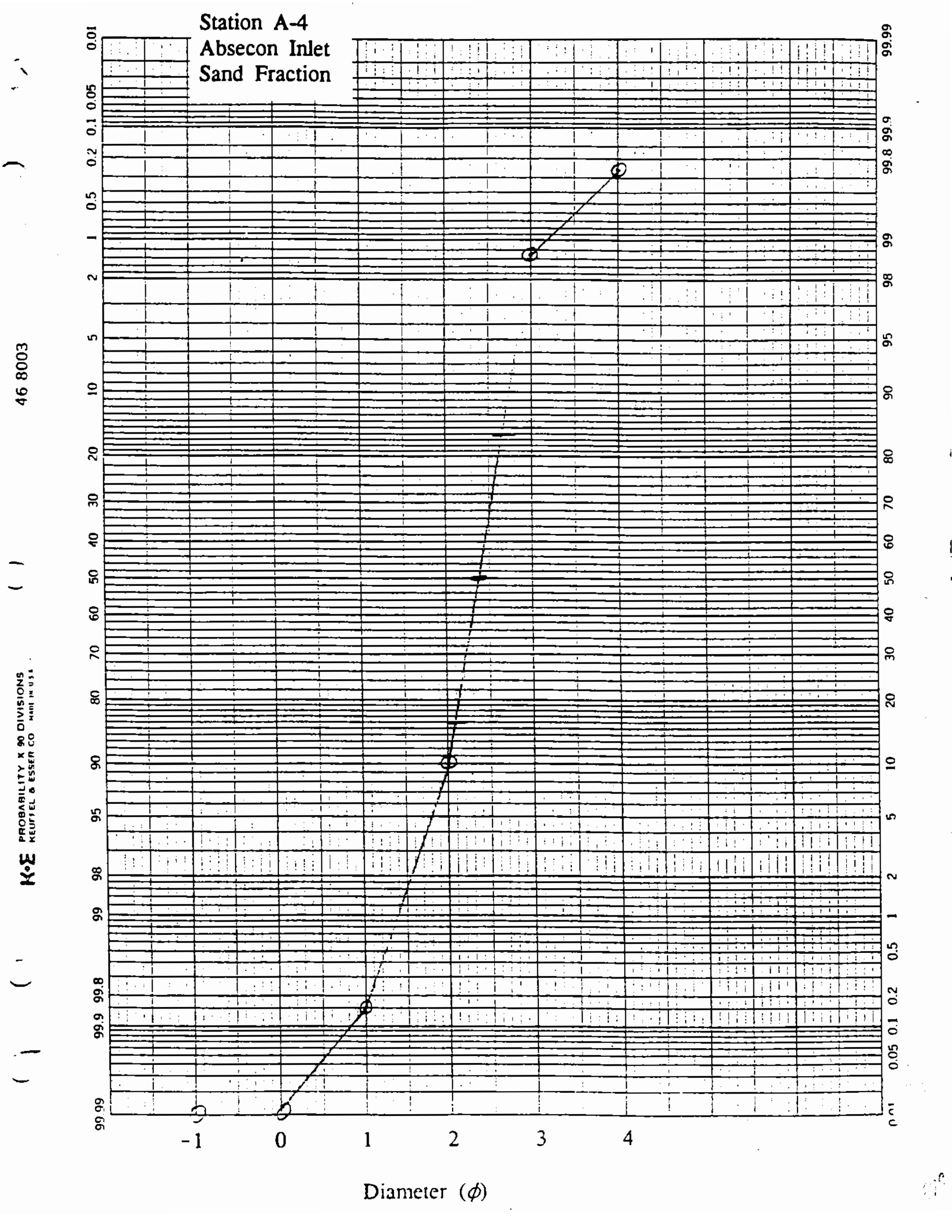
Time s	Latitude	Longitude	Depth m	Temper C	Salini PSU	pH pH	Disso mg/L
394-74.41	39.35033	-74.39584	0.67	15.793	31.574	8.04	6.84
39476.13			0.82	15.784	31.574	8.03	6.79
39476.63			0.97	15.785	31.580	8.03	6.77
39477.12	39.35033	-74.39584	1.08	15.779	31.581	8.03	6.58
39477.61			1.21	15.771	31.584	8.03	6.41
39478.10			1.35	15.771	31.591	8.03	6.44
39478.59			1.58	15.781	31.583	8.03	6.49
39479.09	39.35033	-74.39584	1.78	15.776	31.573	8.03	6.54
39479.58			1.92	15.763	31.591	8.03	6.60
39480.07			1.96	15.771	31.573	8.03	6.65
39480.56			2.13	15.763	31.581	8.03	6.64
39481.05	39.35033	-74.39584	2.28	15.758	31.580	8.03	6.63
39481.55			2.44	15.749	31.591	8.04	6.63
39482.04			2.58	15.755	31.582	8.03	6.62
39482.53			2.79	15.752	31.589	8.03	6.65
39483.02	39.35033	-74.39584	2.98	15.763	31.583	8.03	6.69
39483.52			3.30	15.771	31.598	8.03	6.72
39484.01			3.61	15.763	31.604	8.03	6.75
39484.50			3.79	15.784	31.587	8.03	6.80
39484.99	39.35033	-74.39584	3.88	15.779	31.587	8.03	6.80
39485.48			3.96	15.774	31.599	8.03	6.76
39485.98			4.18	15.771	31.597	8.03	6.73
39486.47			4.42	15.771	31.601	8.04	6.72
39486.96	39.35033	-74.39584	4.47	15.779	31.590	8.03	6.73
39487.45			4.63	15.779	31.601	8.03	6.73
39487.95			4.81	15.782	31.599	8.03	6.74
39488.44			4.98	15.787	31.595	8.03	6.75
39488.93	39.35033	-74.39584	5.19	15.787	31.598	8.04	6.77
39489.42			5.42	15.790	31.599	8.03	6.79
39489.91			5.66	15.787	31.602	8.03	6.74
39490.41			5.71	15.790	31.595	8.03	6.65
39490.90	39.35033	-74.39567	5.67	15.784	31.607	8.03	6.56
39491.39			5.73	15.789	31.600	8.03	6.54
39491.88			5.82	15.793	31.593	8.04	6.55
39492.38			5.96	15.768	31.620	8.04	6.55
39492.87	39.35033	-74.39567	6.10	15.790	31.599	8.04	6.56
39493.36			6.30	15.790	31.602	8.03	6.59
39493.85			6.43	15.790	31.602	8.04	6.62
39494.34			6.59	15.798	31.603	8.04	6.64
39507.39	39.35033	-74.39567	6.75	15.819	31.586	8.04	6.65

APPENDIX C
CUMULATIVE GRAIN-SIZE DISTRIBUTION PLOTS

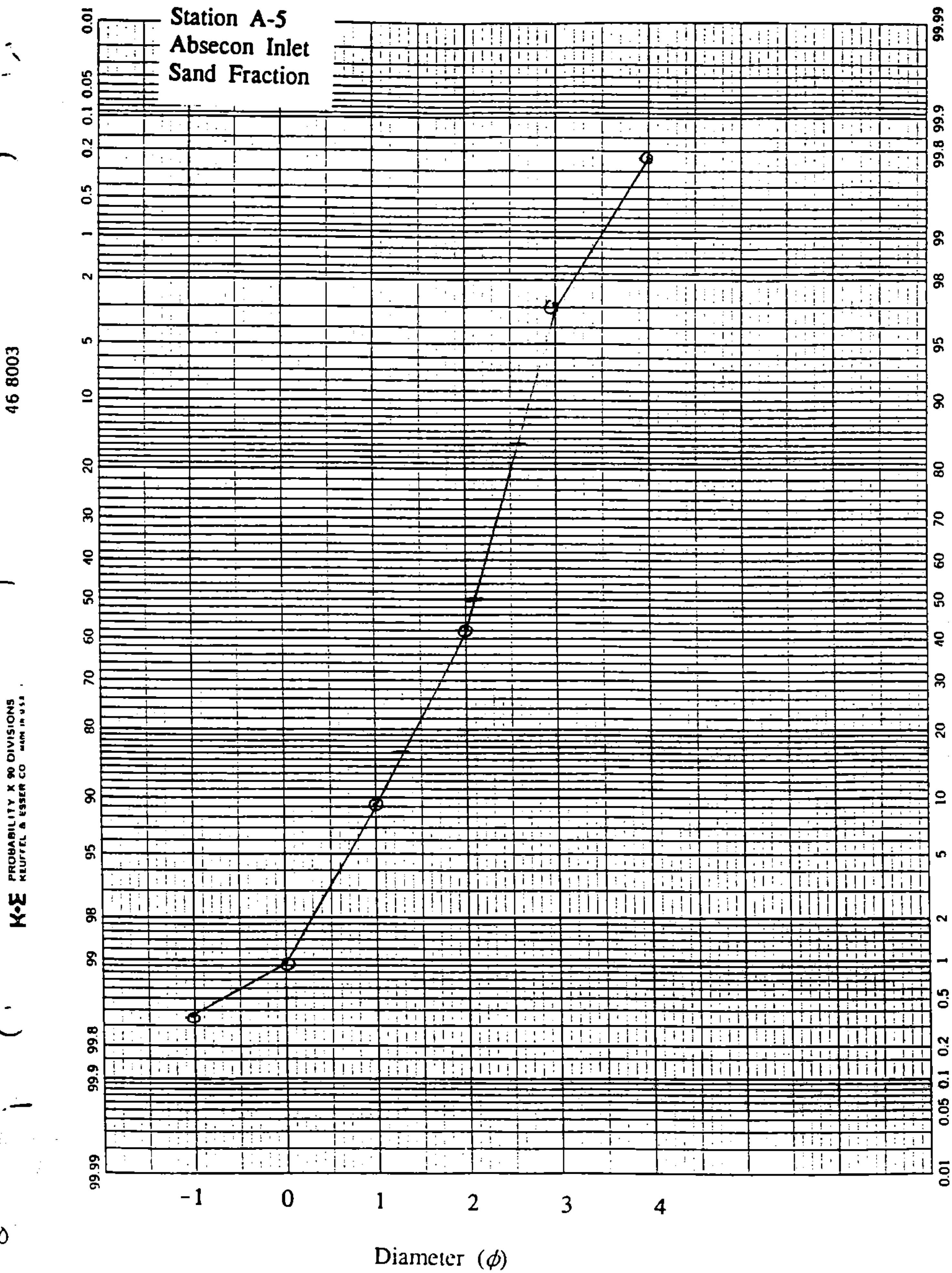

Station A-1
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.


Station A-2
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)


Station A-3
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (φ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.

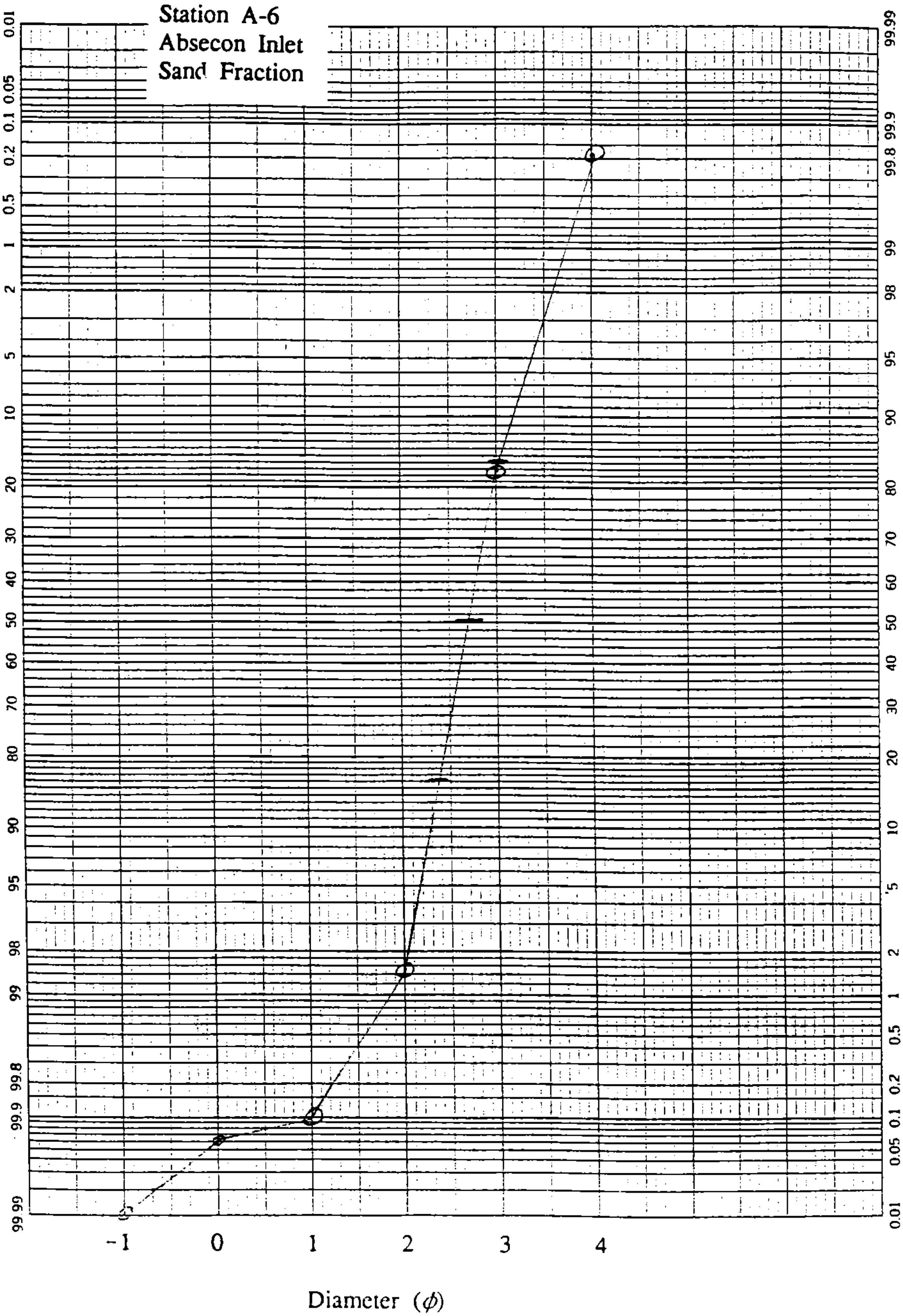


Station A-4
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.



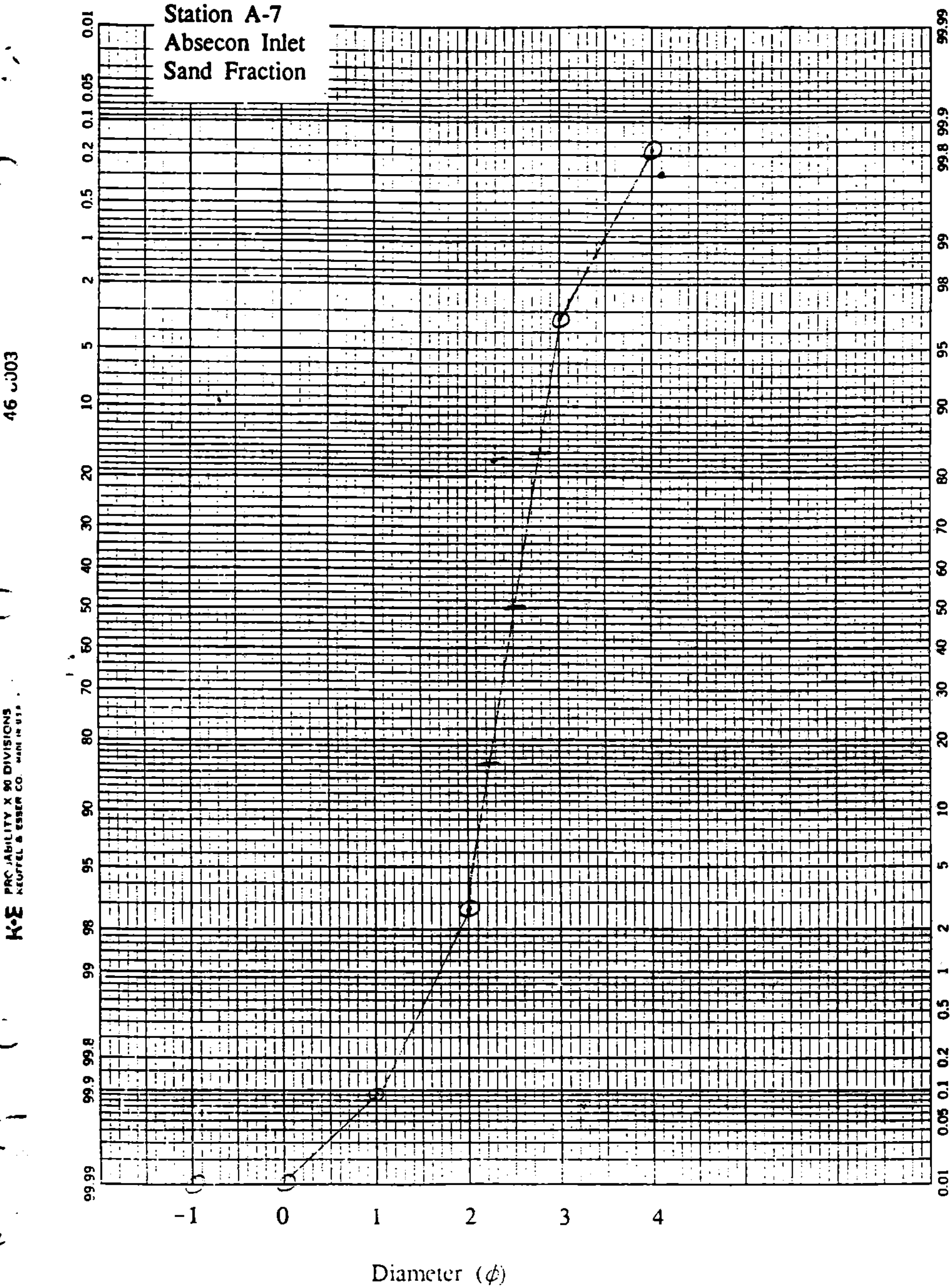
Station A-5
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.

380



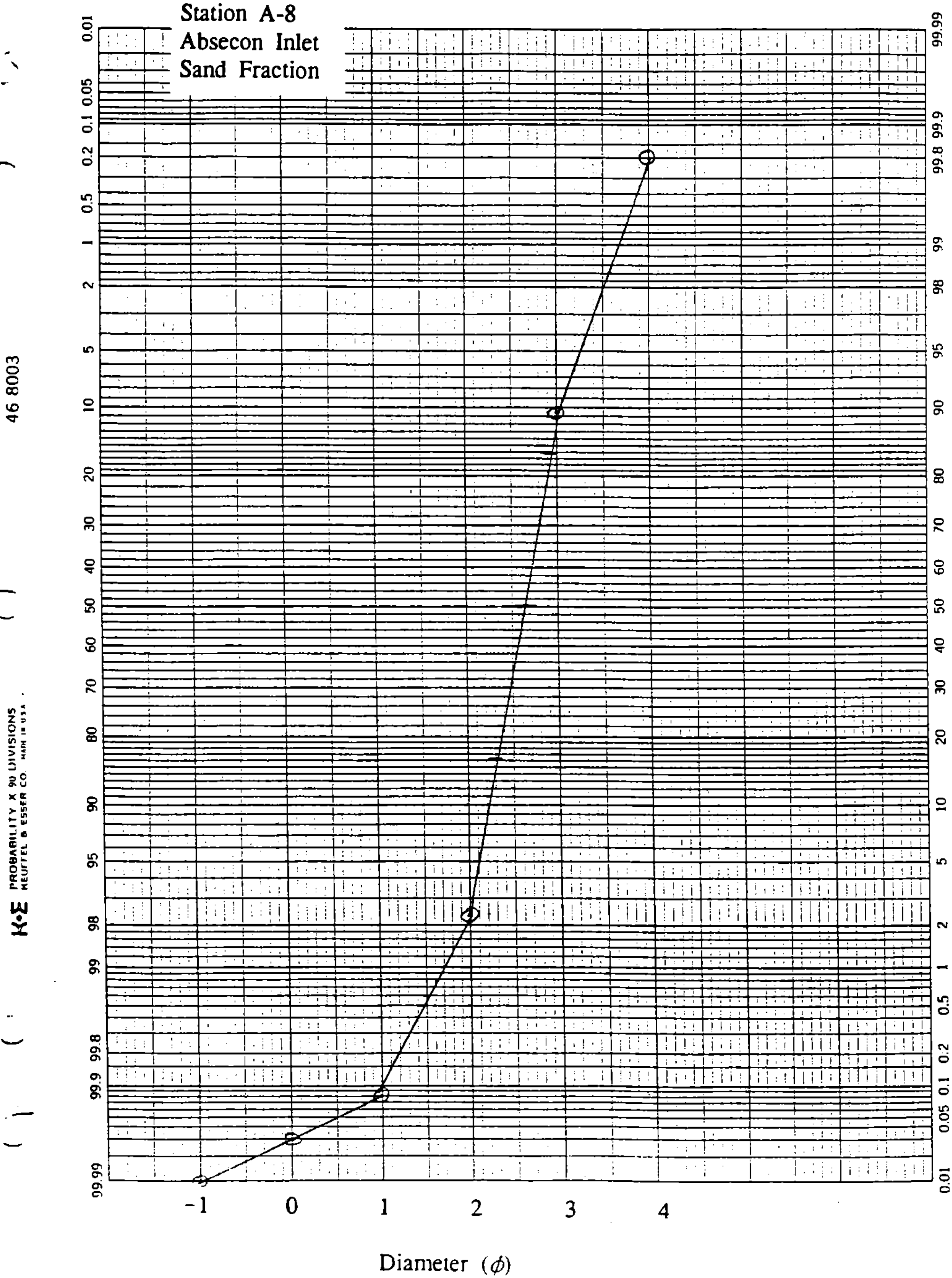
46 8003

K+E PROBABILITY X 90 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A.

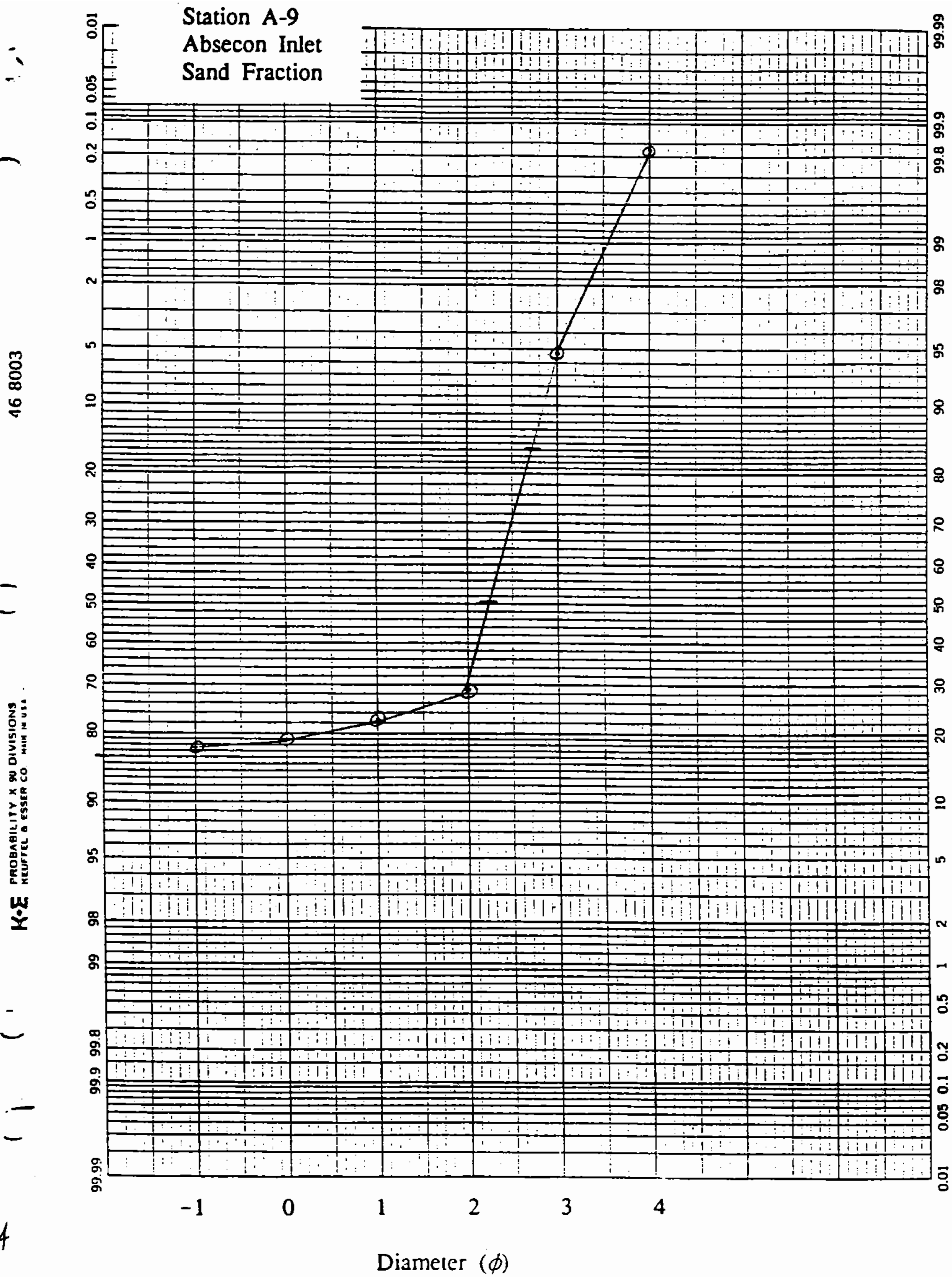


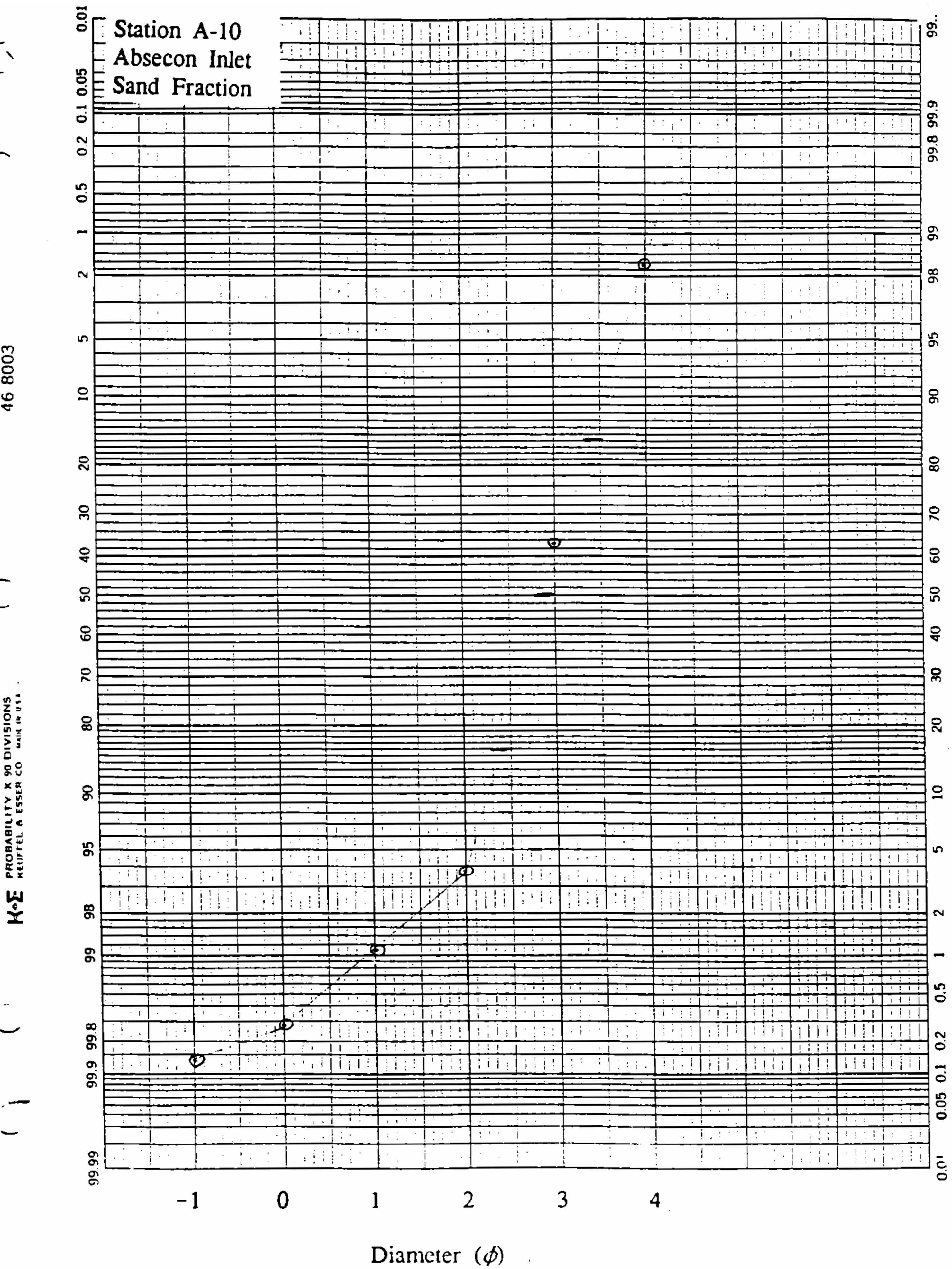
Station A-7
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8003

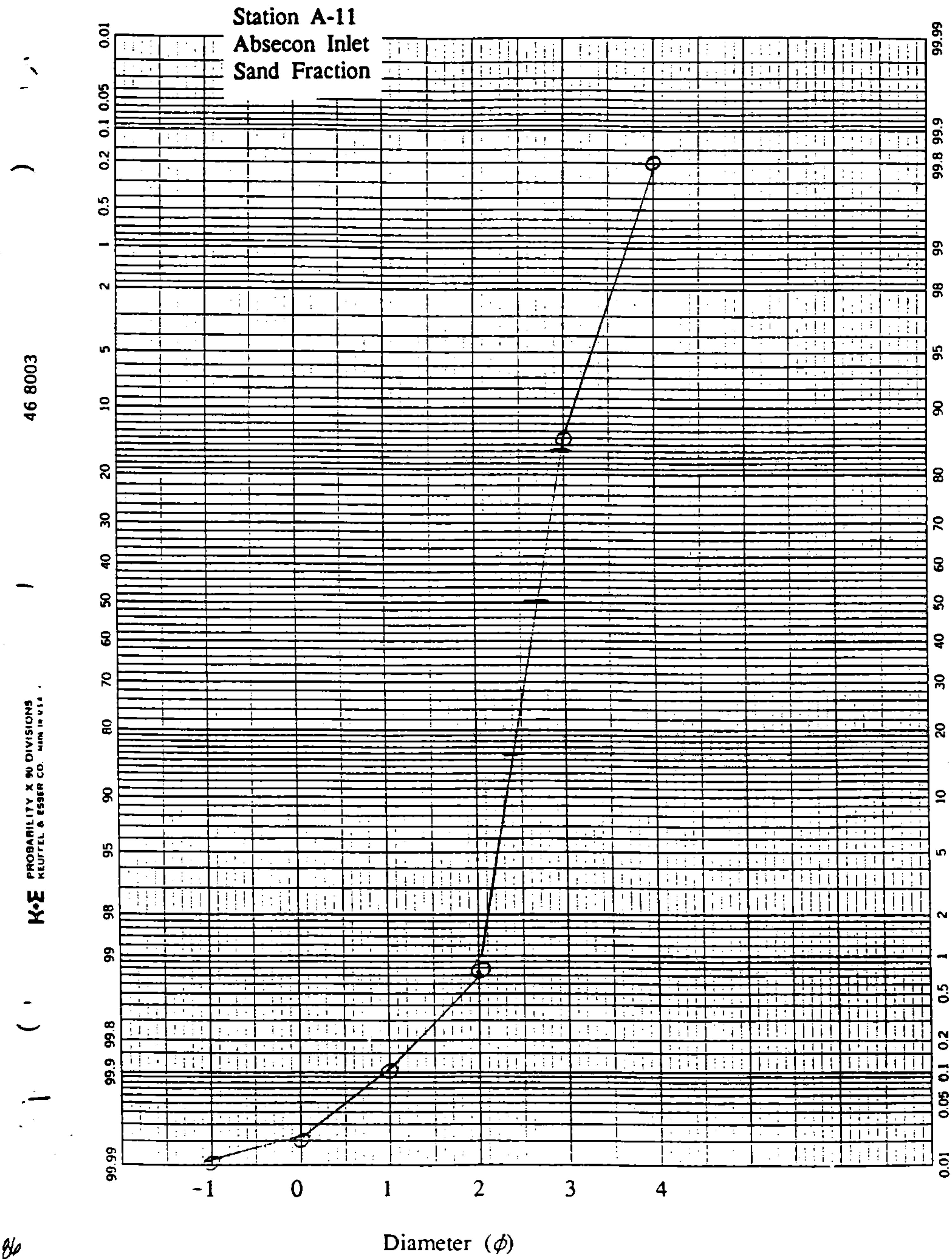
82



Station A-8
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

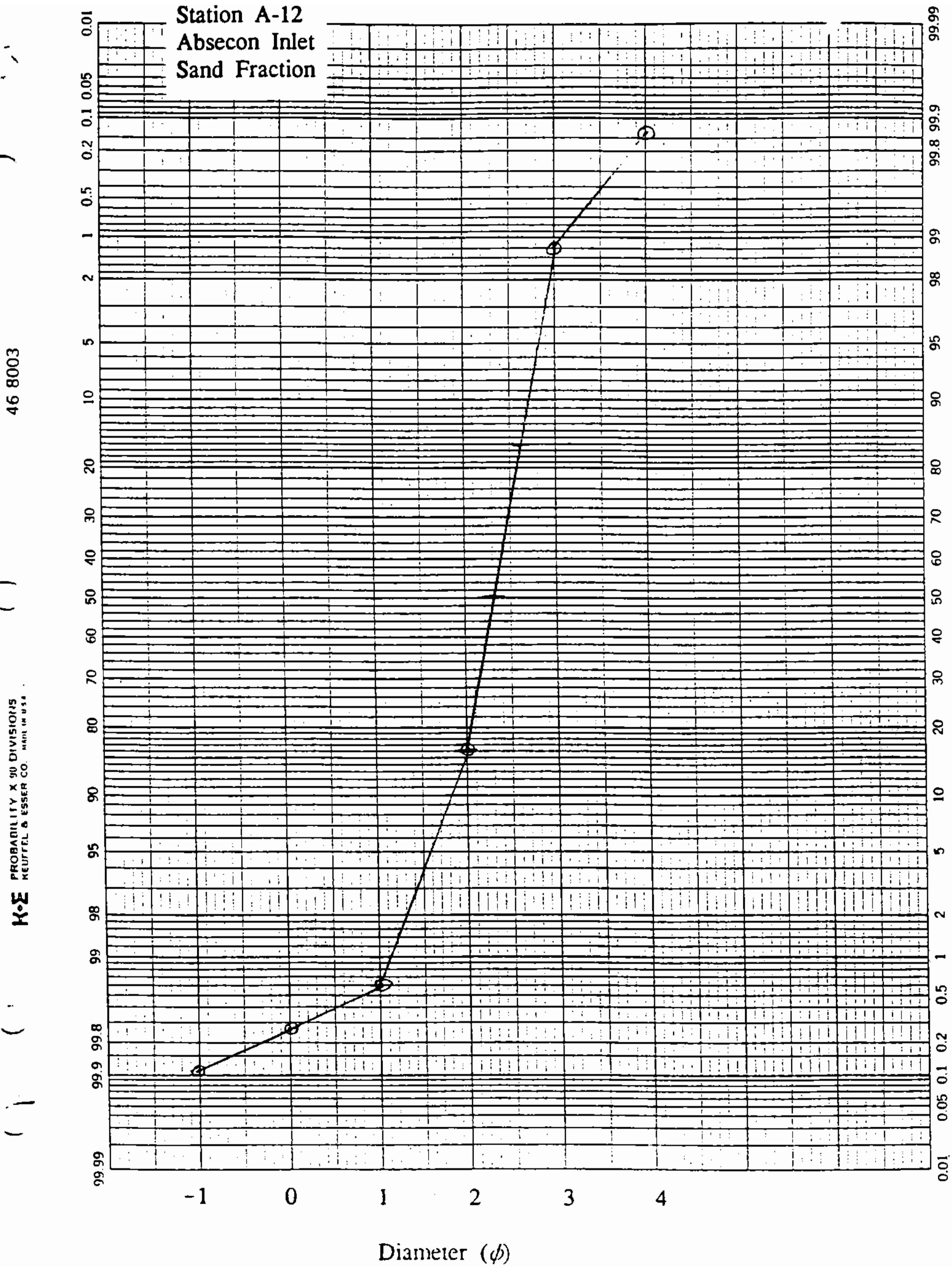

Station A-9
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.


Station A-10
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
−1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

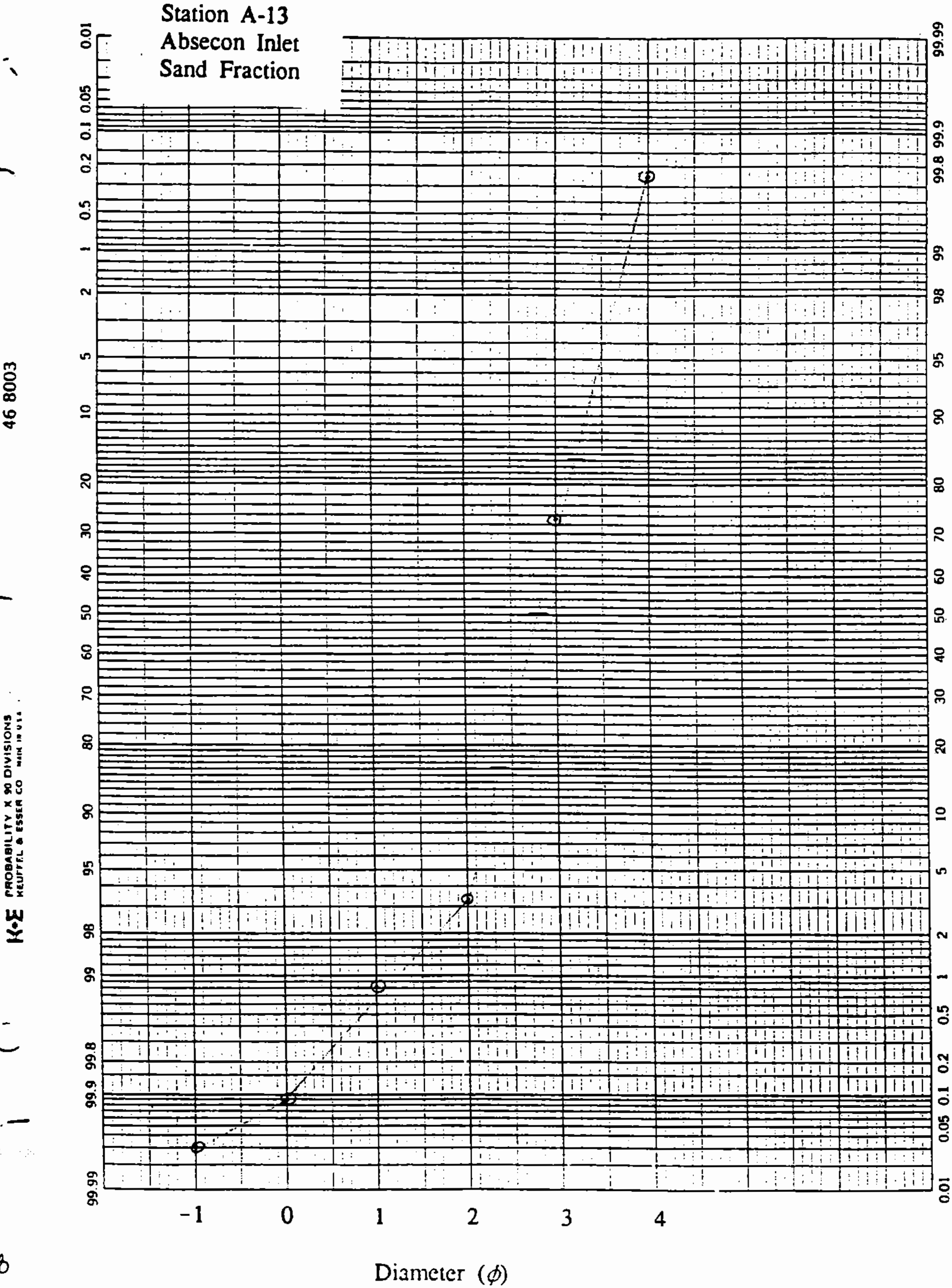


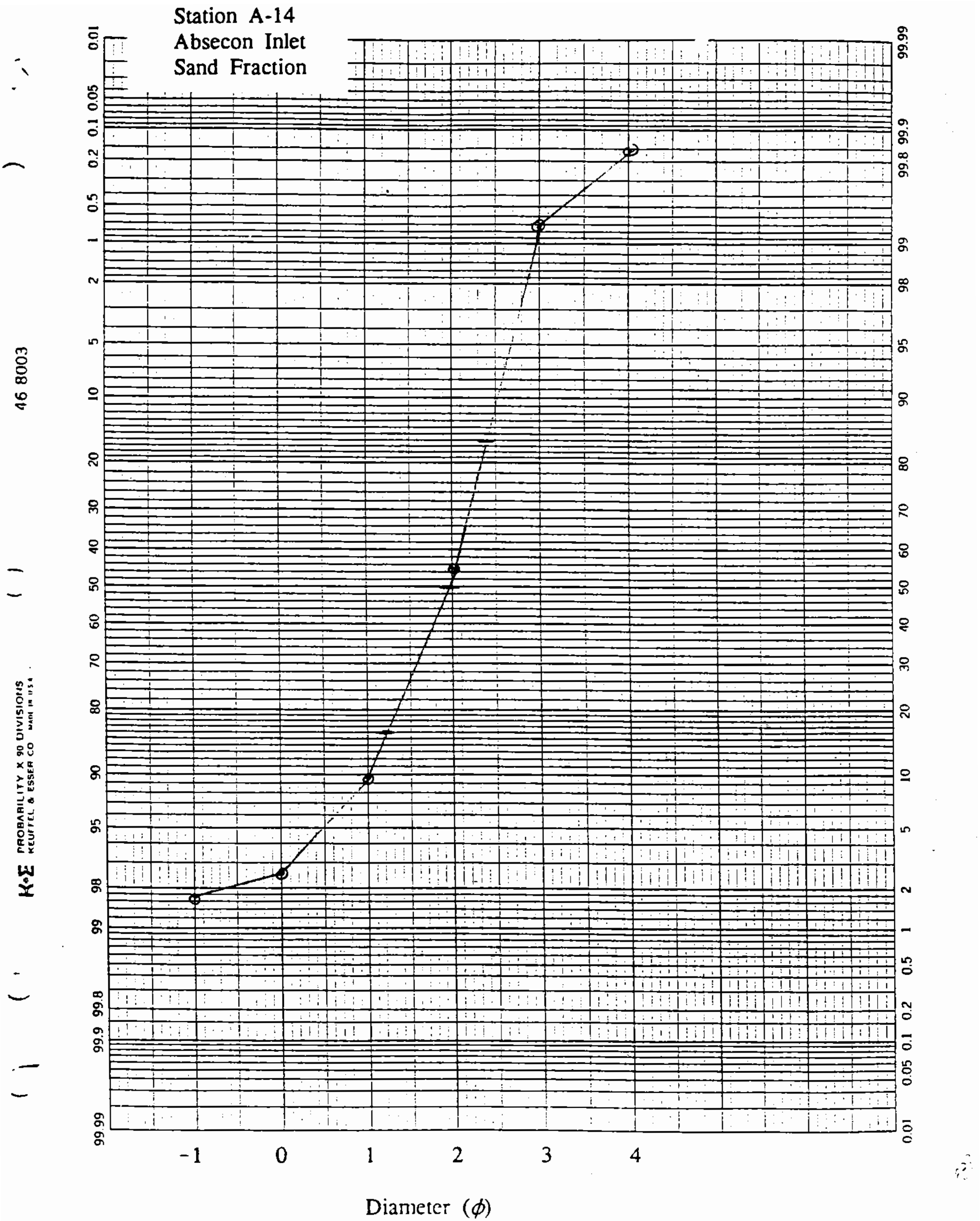
Station A-11
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K·E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

86

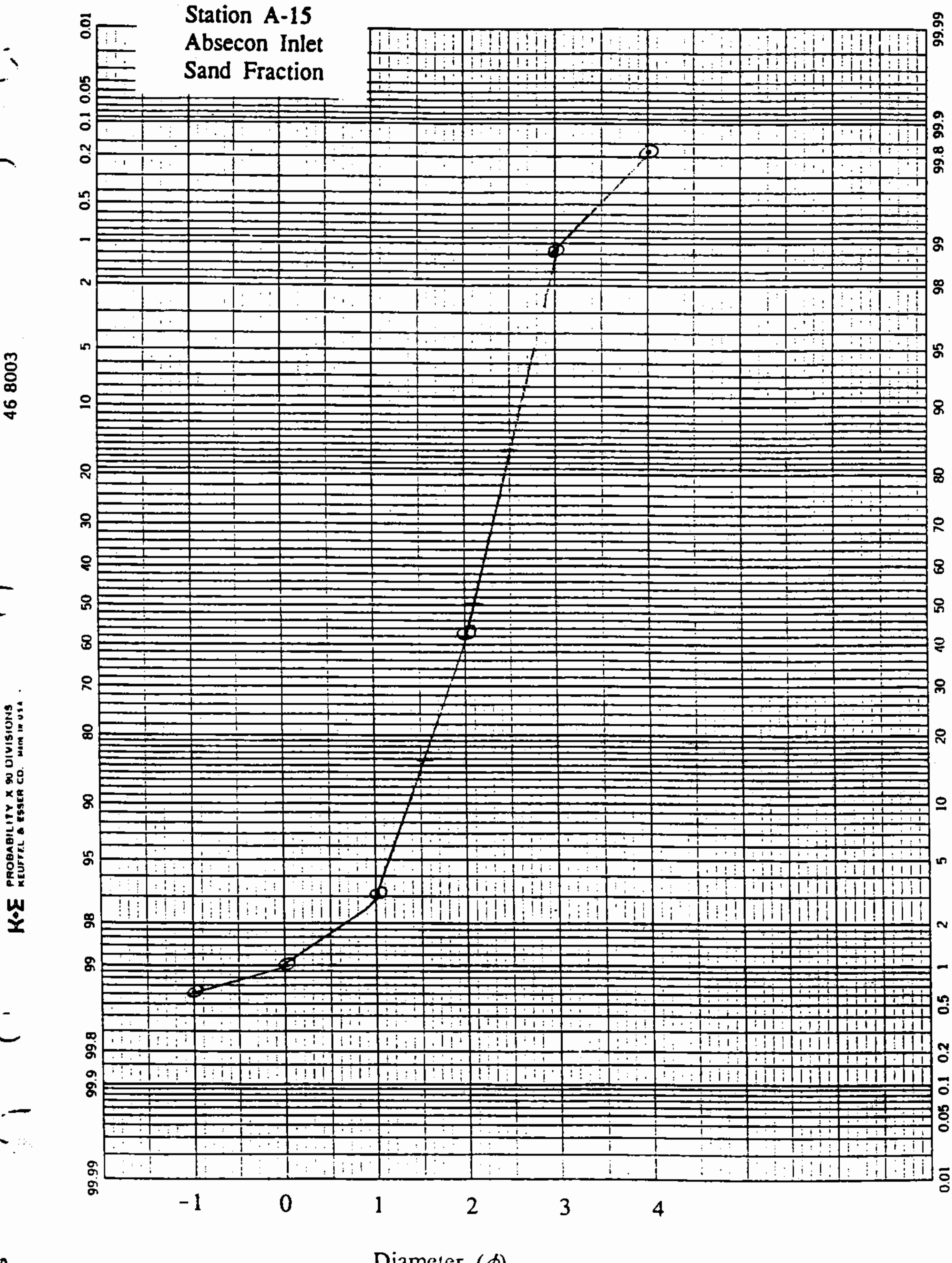


Station A-12
Absecon Inlet
Sand Fraction
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99


Station A-13
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
−1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.

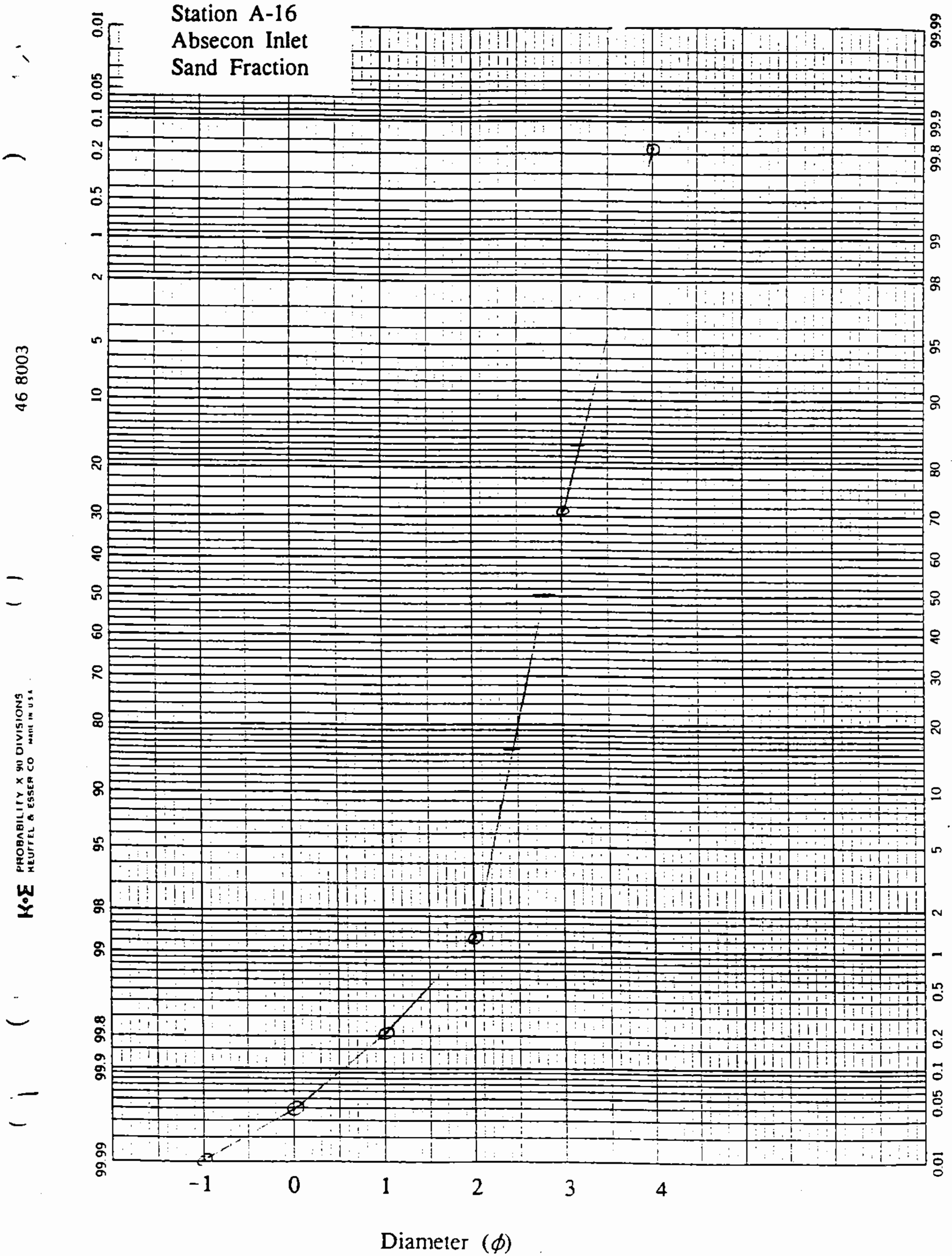


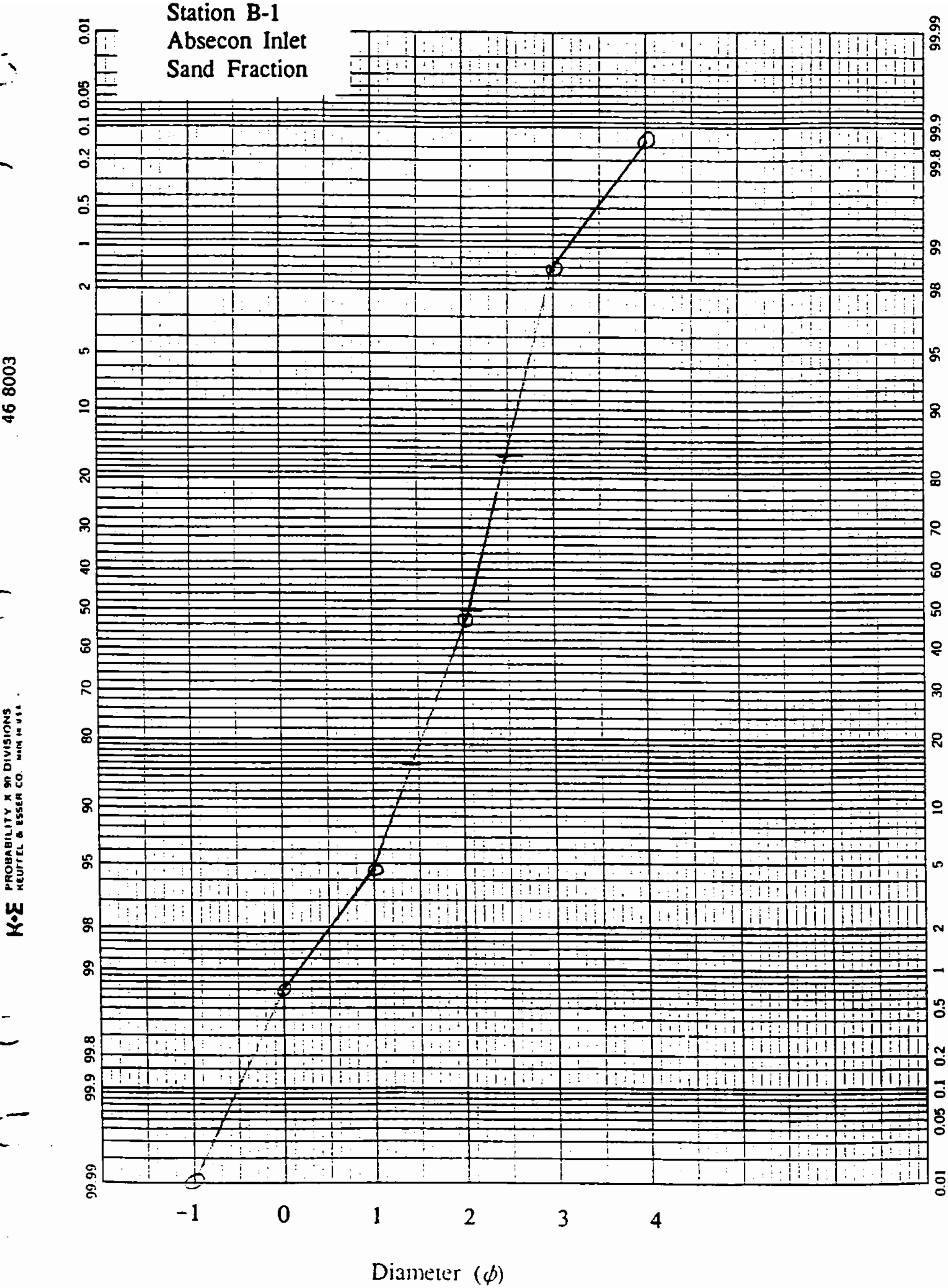
Station A-14
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.



Station A-15
Absecon Inlet
Sand Fraction
46 8003
K-E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN USA
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)

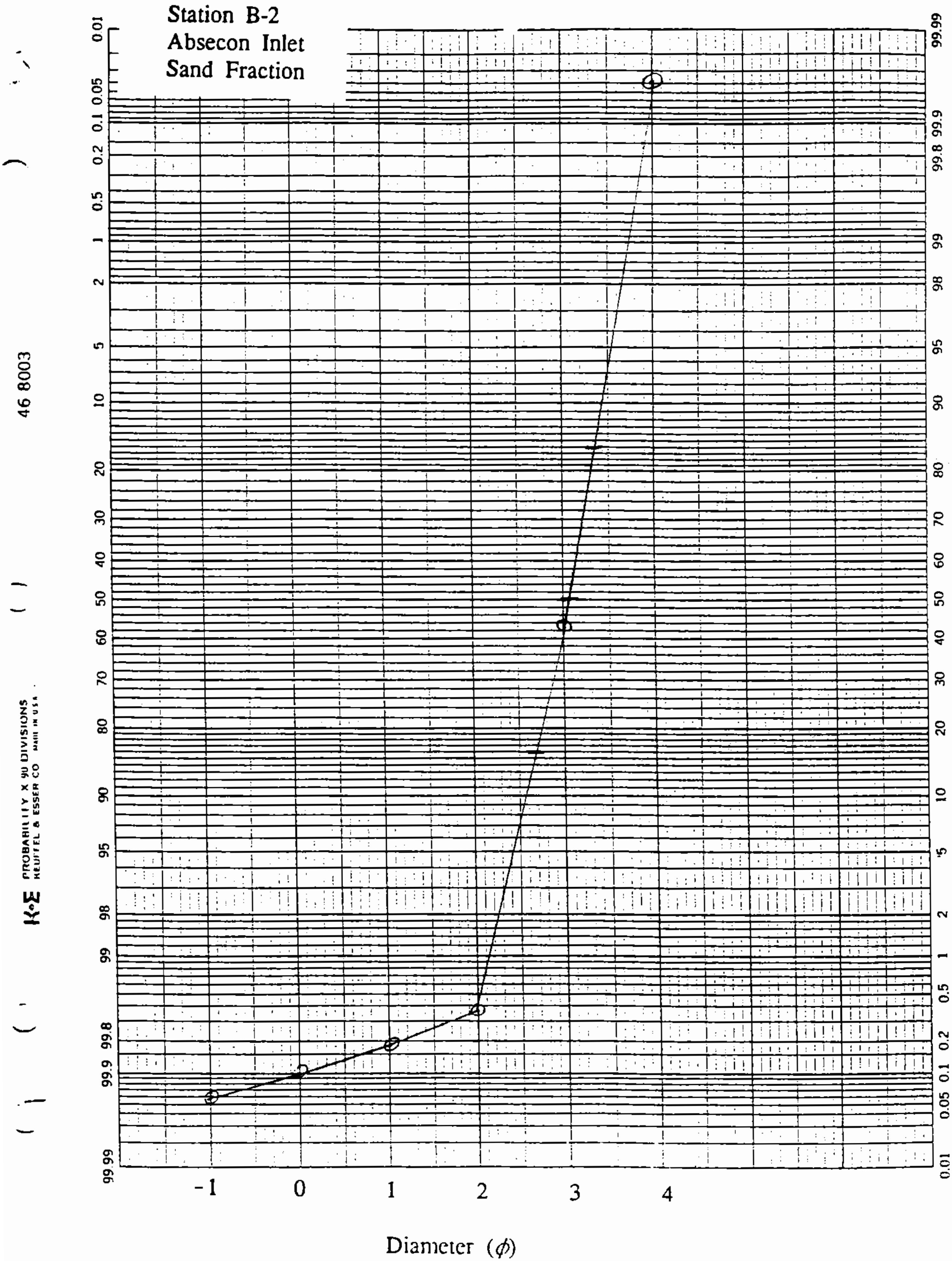
'90

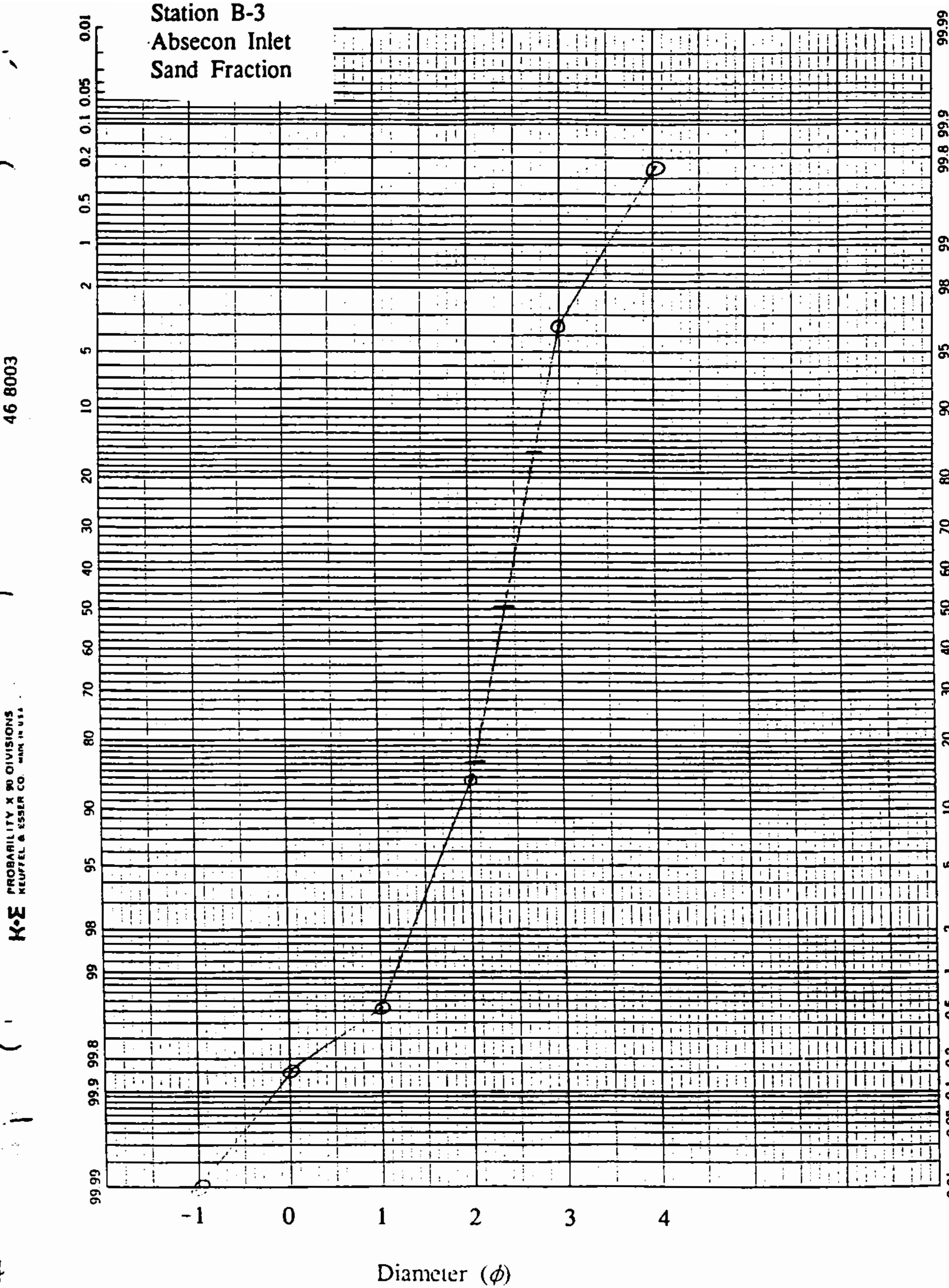

Station A-16
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

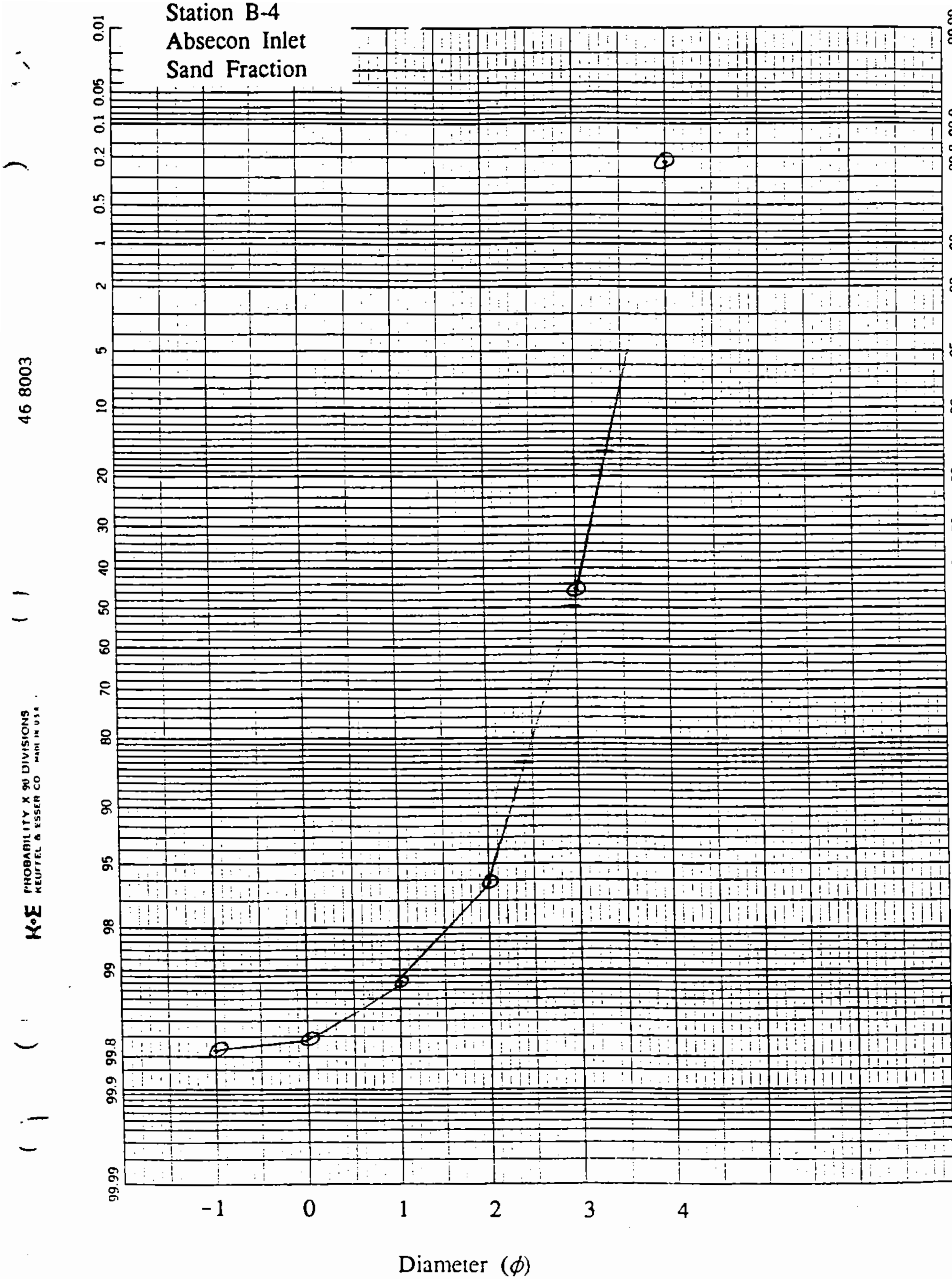


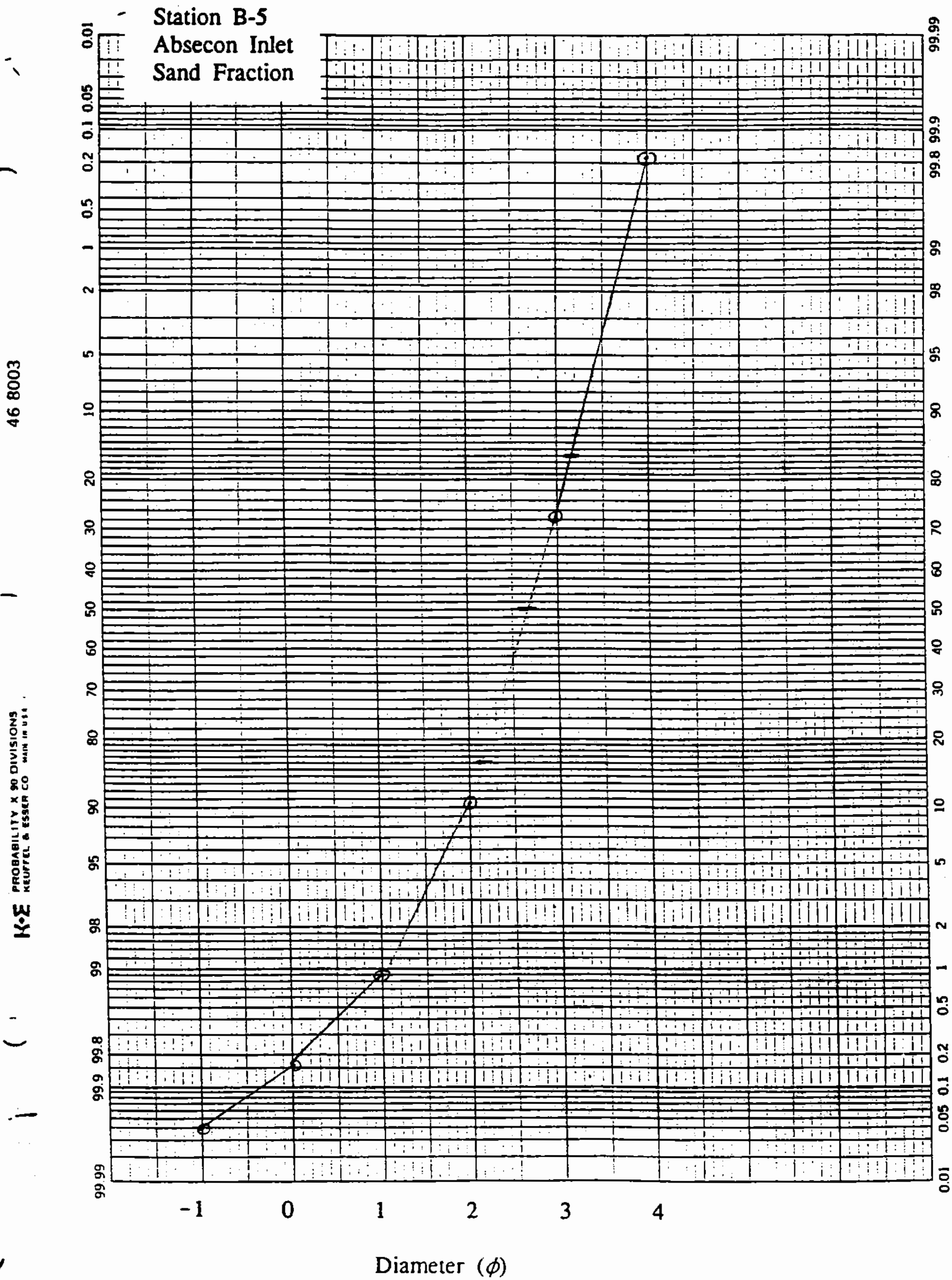
Station B-1
Absecon Inlet
Sand Fraction
K•E PROBABILITY X 90 DIVISIONS KEUFFEL & ESSER CO. MADE IN USA
46 8003
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)

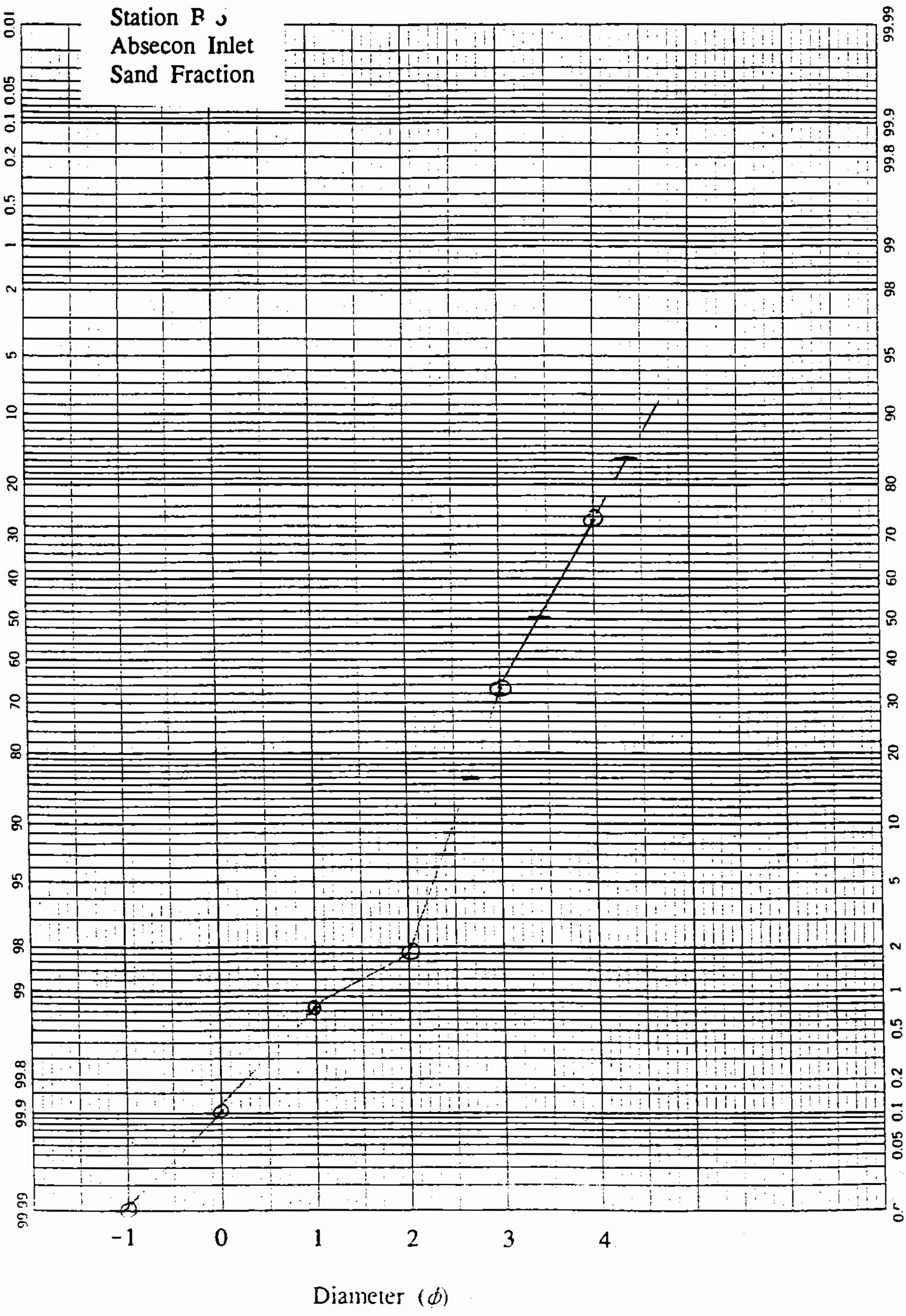
92


Station B-2
Absecon Inlet
Sand Fraction
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.


Station B-3
Absecon Inlet
Sand Fraction
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8003
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (φ)

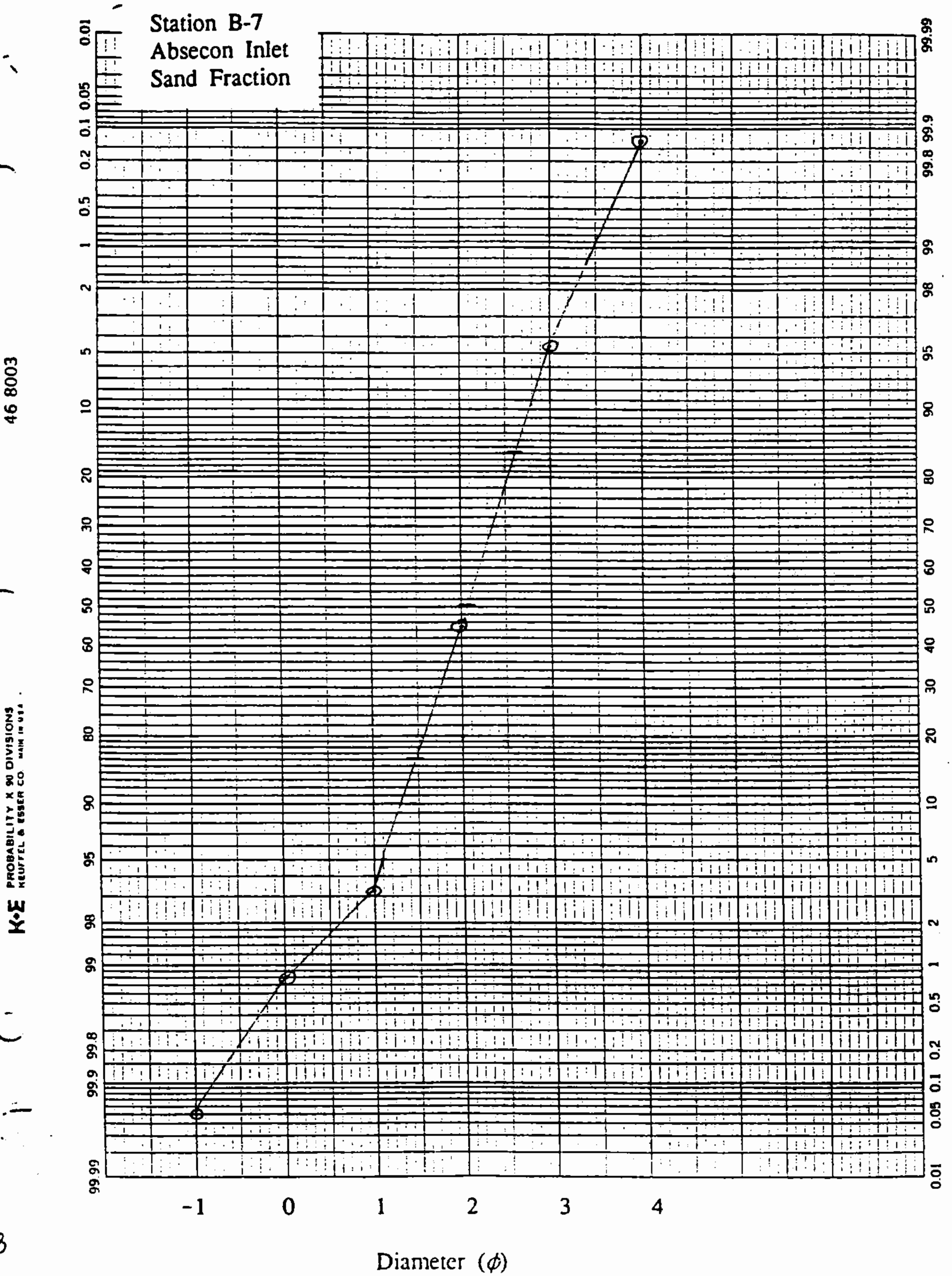

Station B-4
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
-1
0
1
2
3
4
Diameter (ϕ)

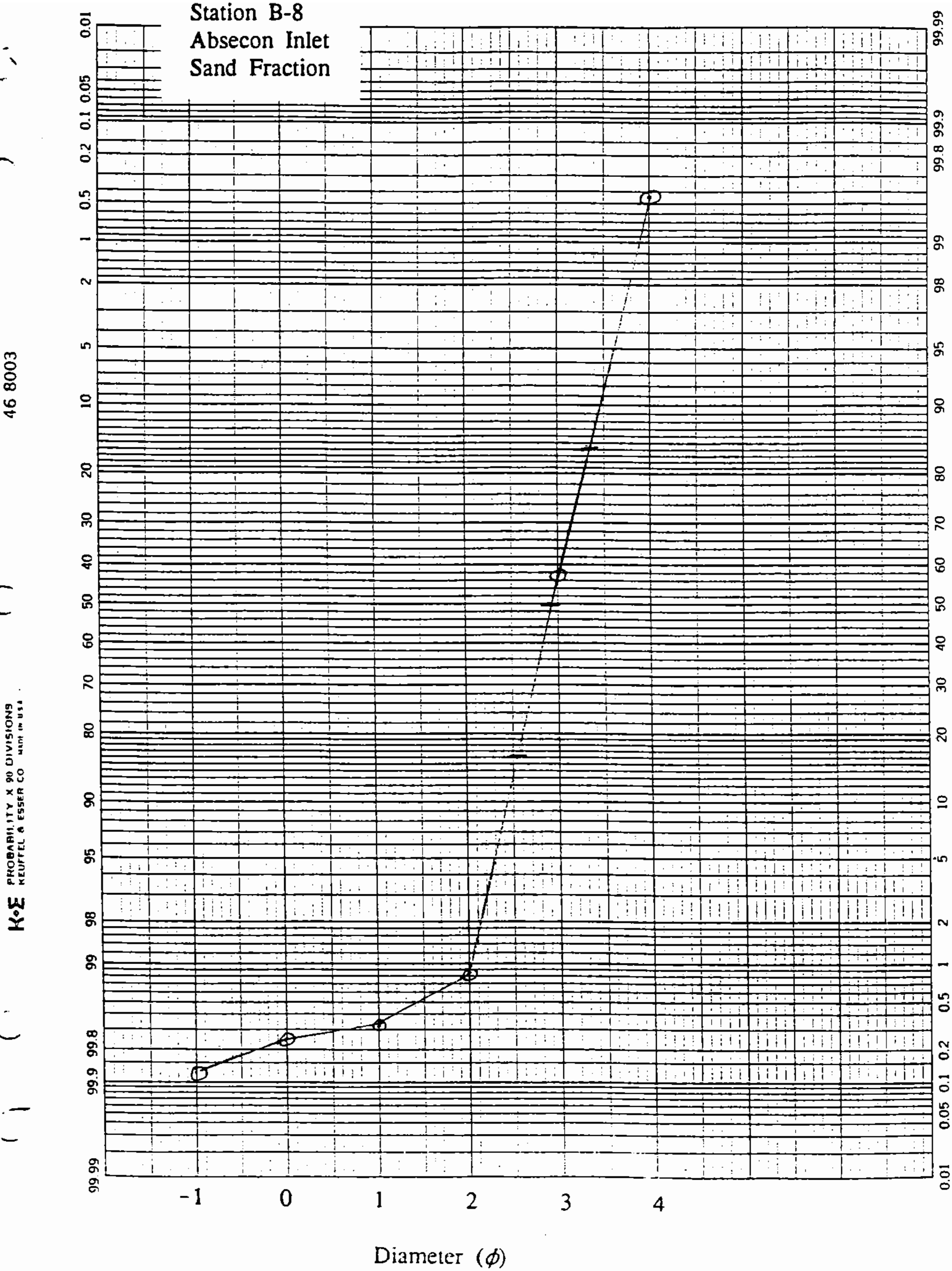

Station B-5
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO.
-1
0
1
2
3
4
Diameter (ϕ)



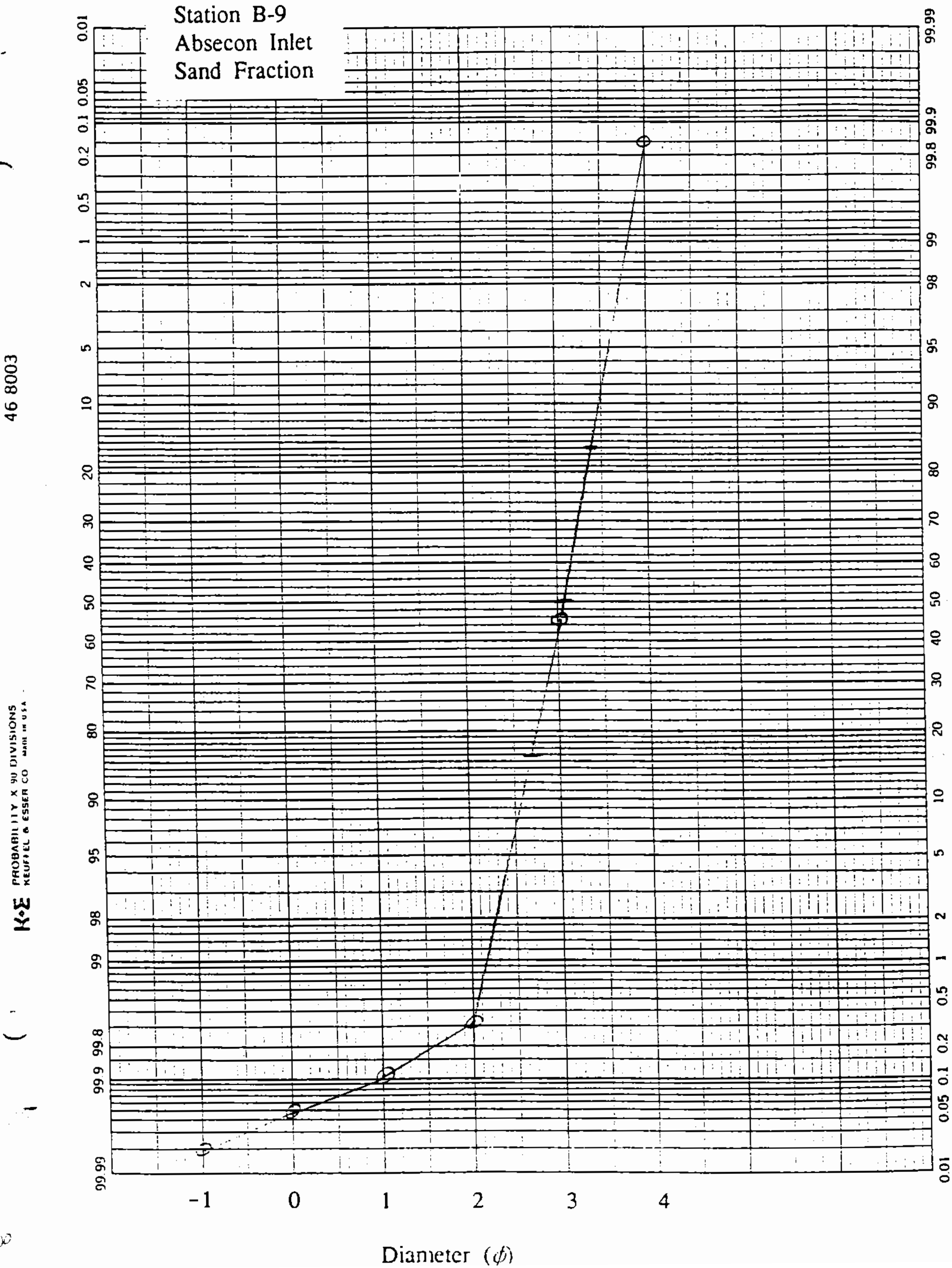
46 8003

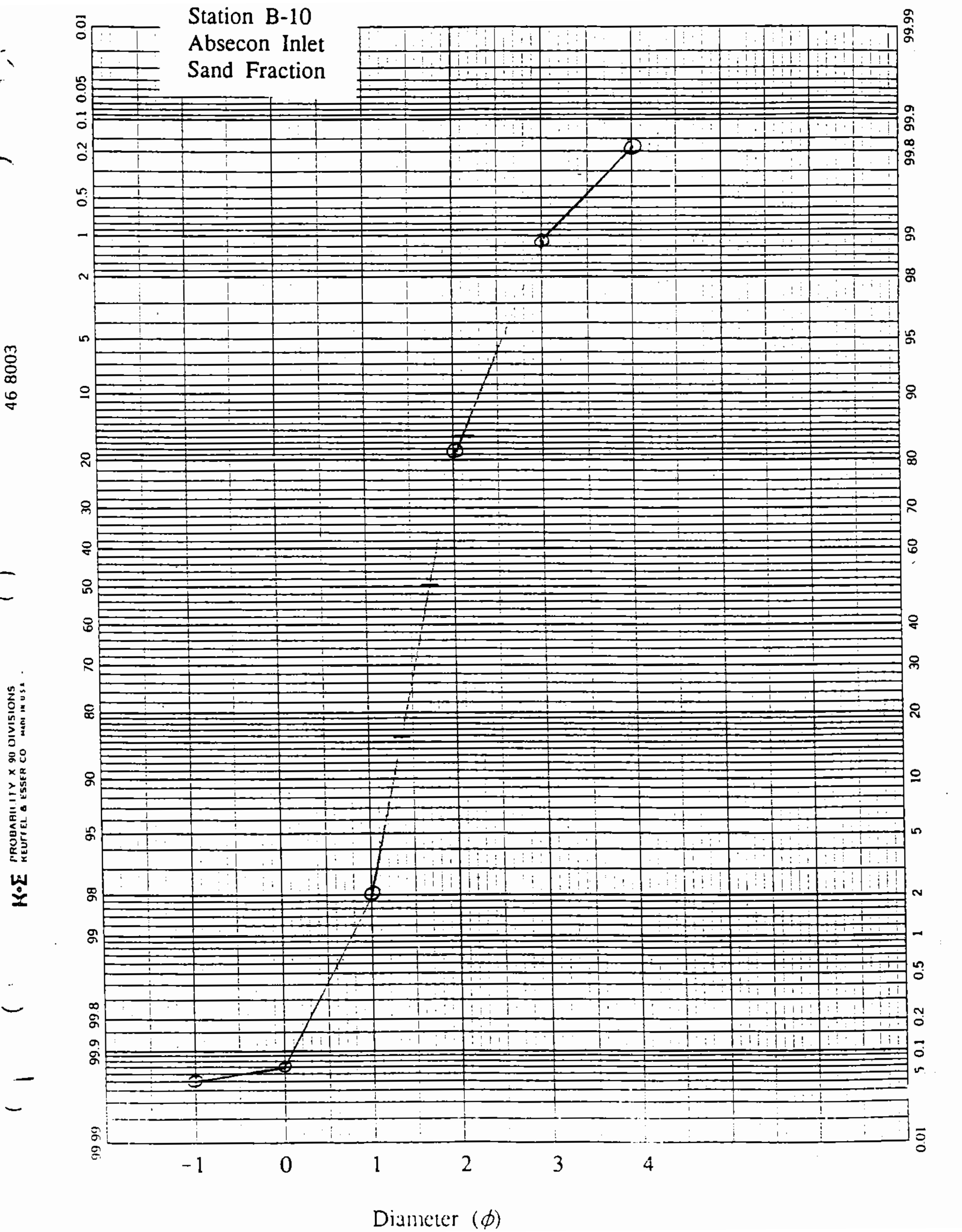
K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.


Station B-7
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
-1
0
1
2
3
4
Diameter (ϕ)

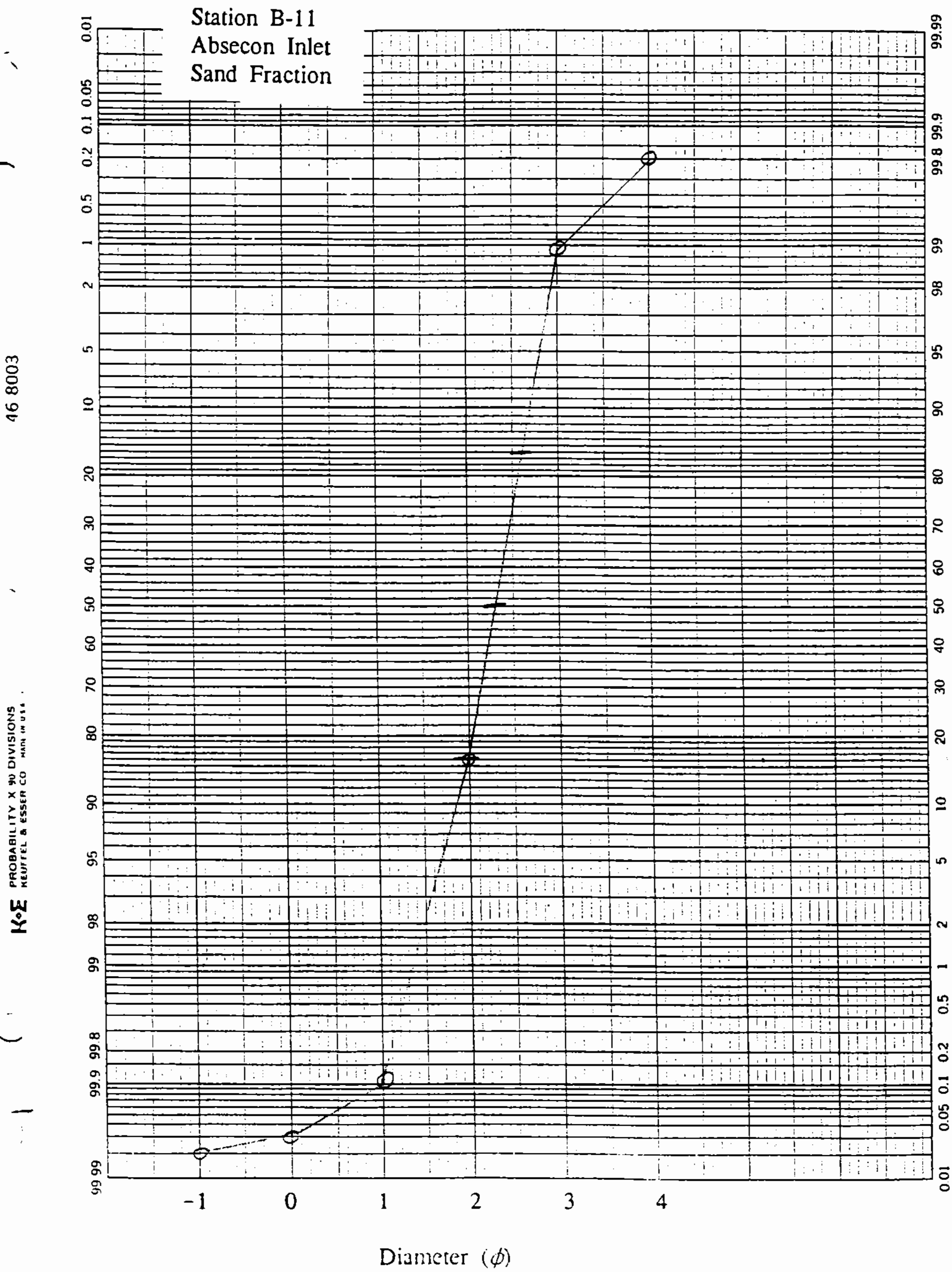


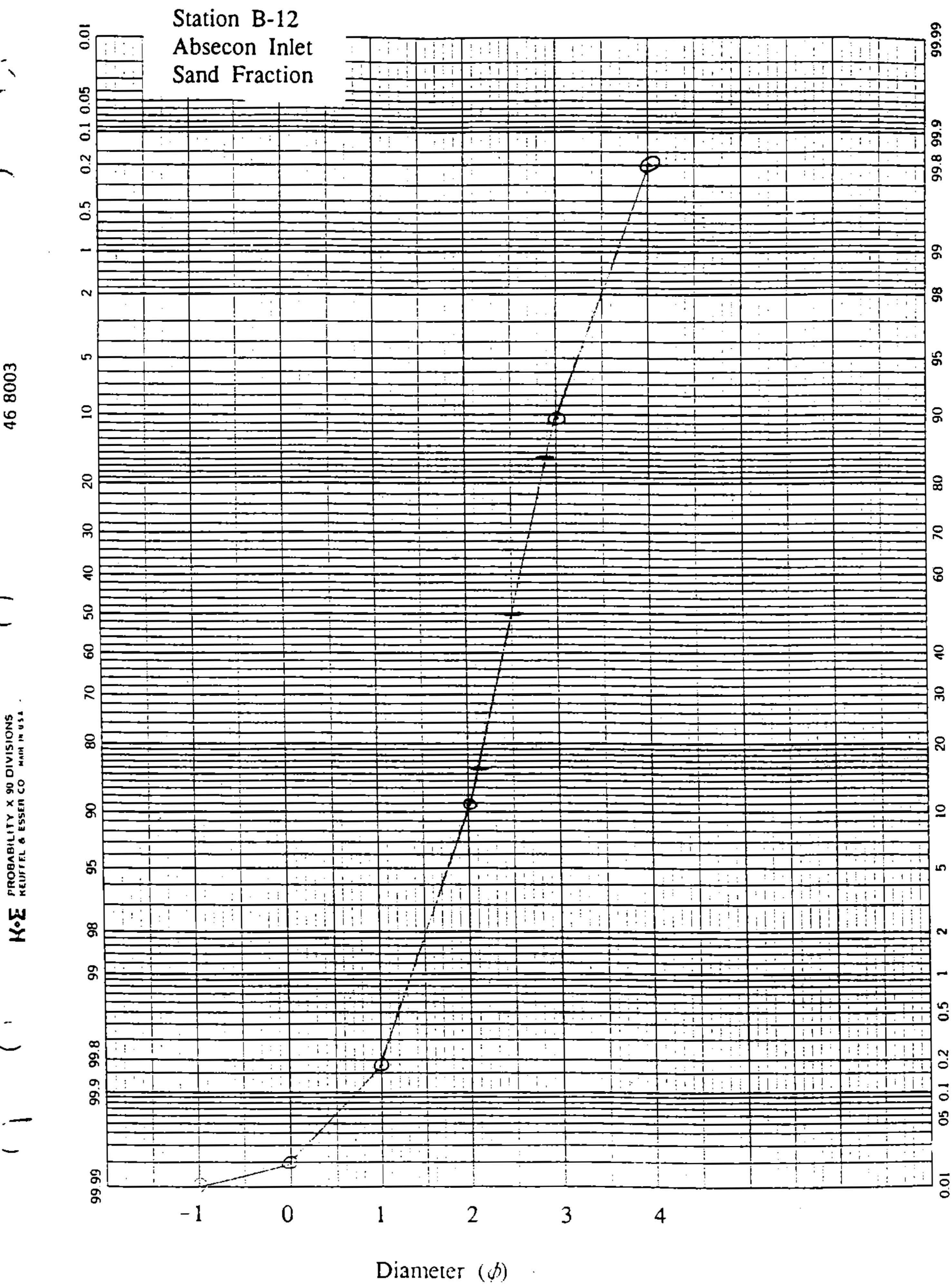
Station B-8
Absecon Inlet
Sand Fraction
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K·E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.


Station B-9
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

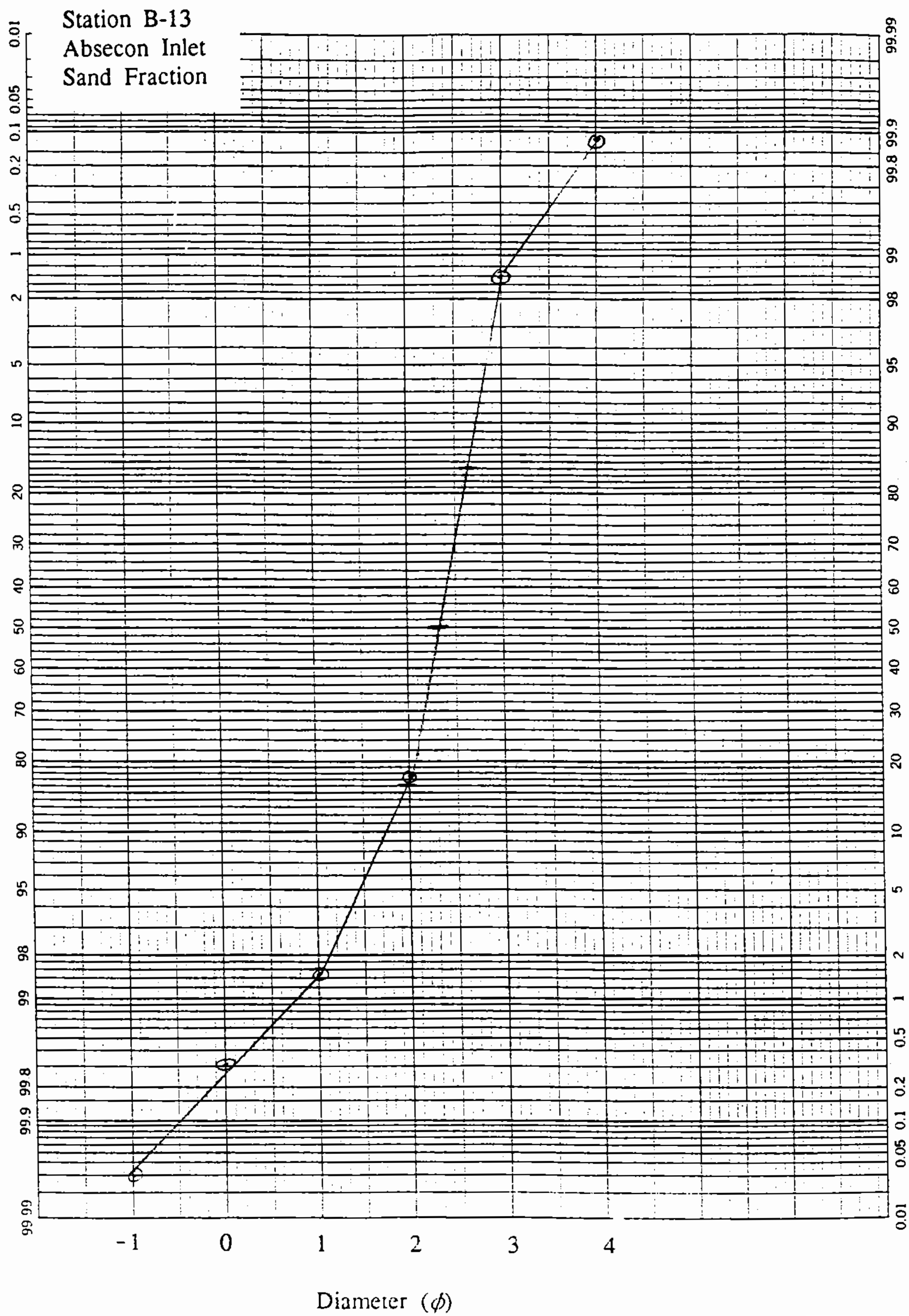


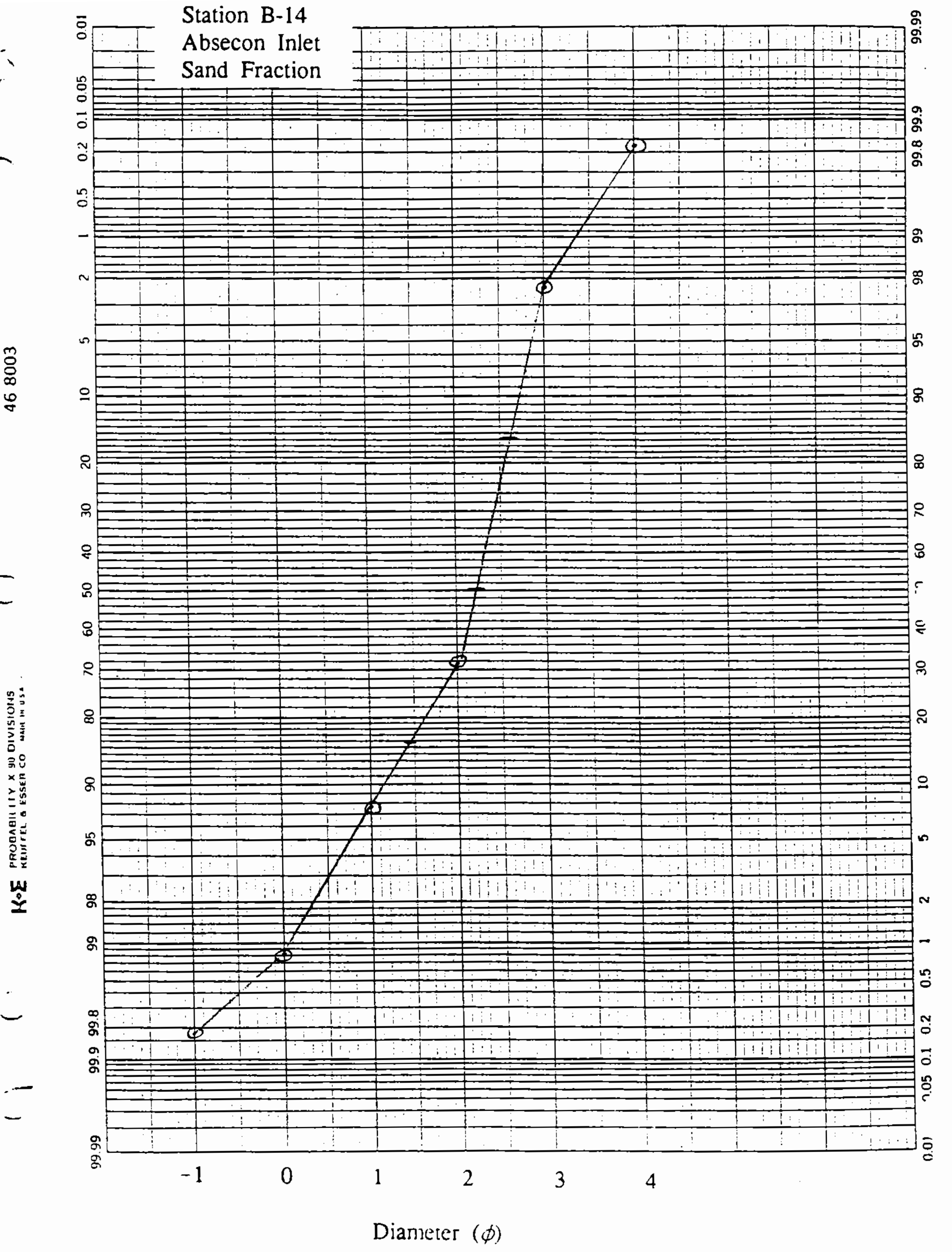
Station B-10
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)

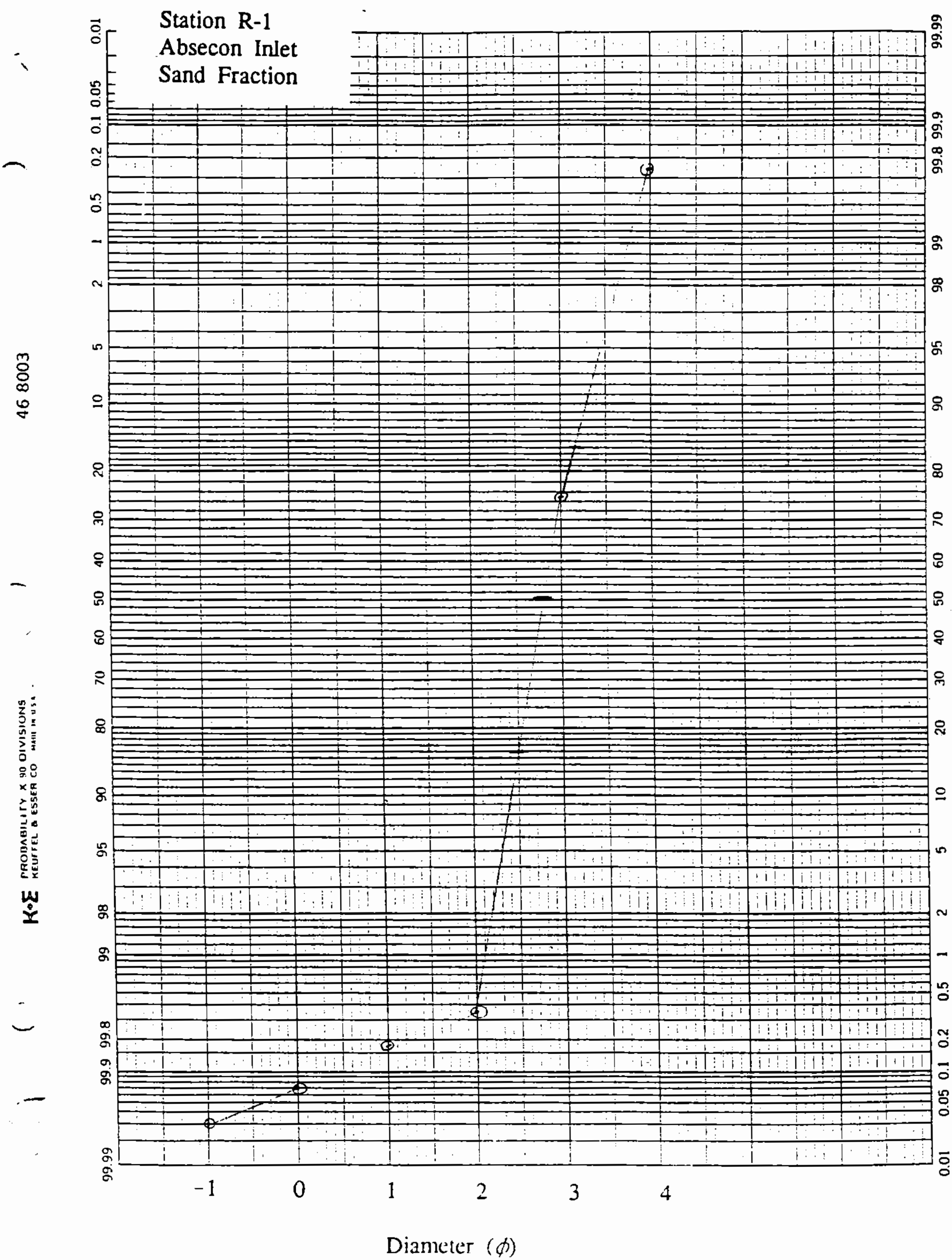

Station B-11
Absecon Inlet
Sand Fraction
Diameter (ϕ)
-1
0
1
2
3
4
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.



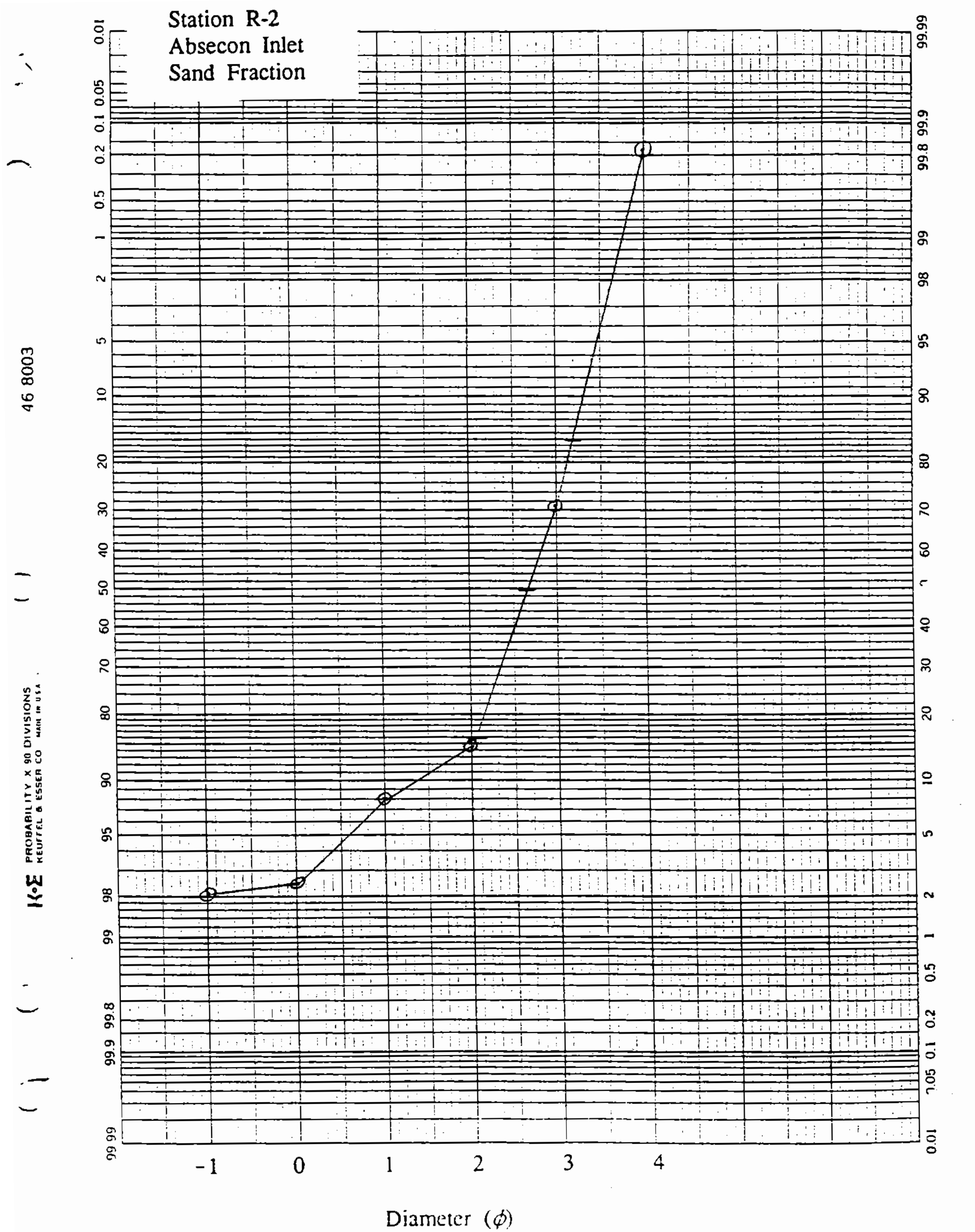
Station B-12
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO MADE IN U.S.A.
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)


Station B-13
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (φ)

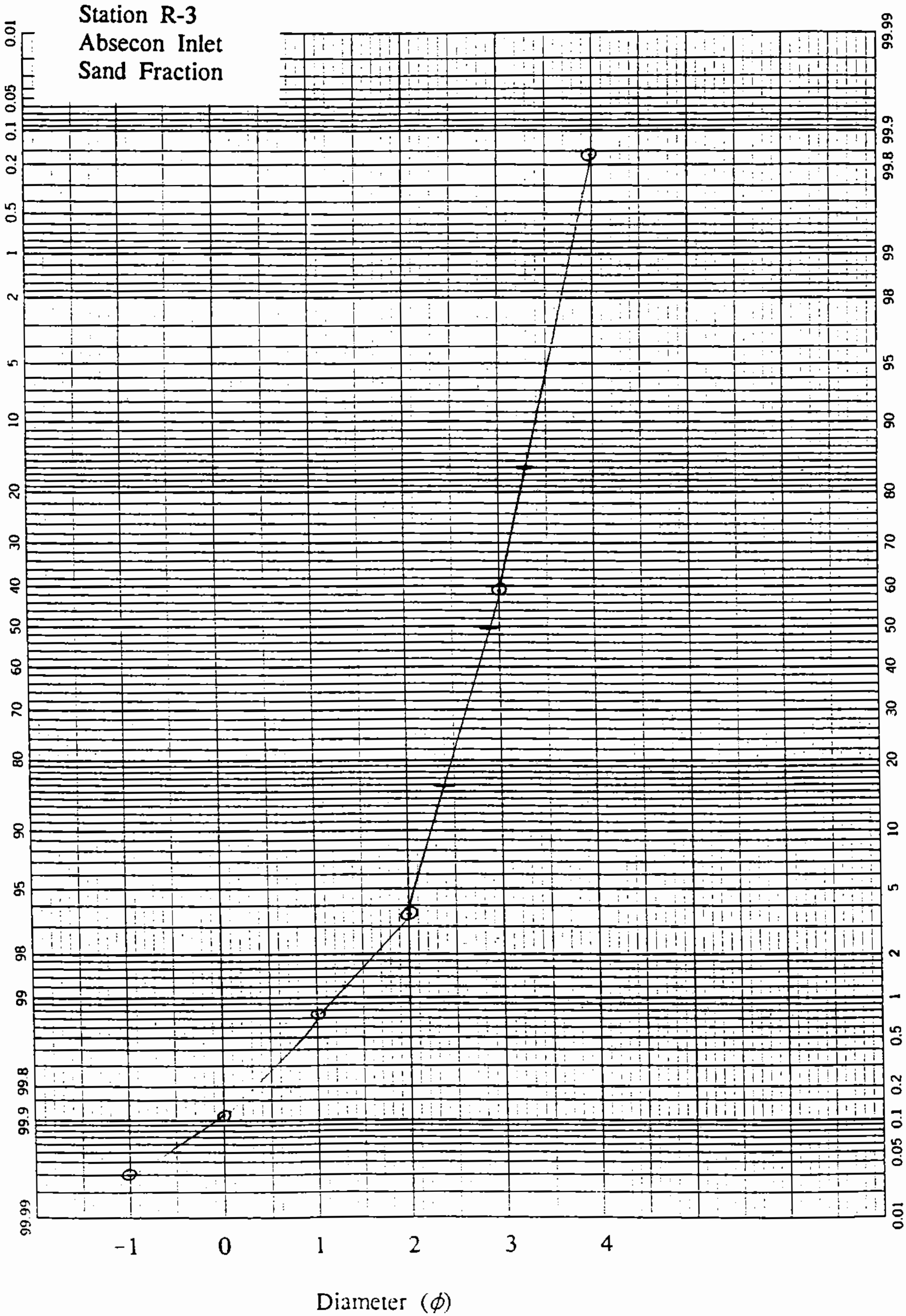

Station B-14
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (φ)
46 8003
K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.



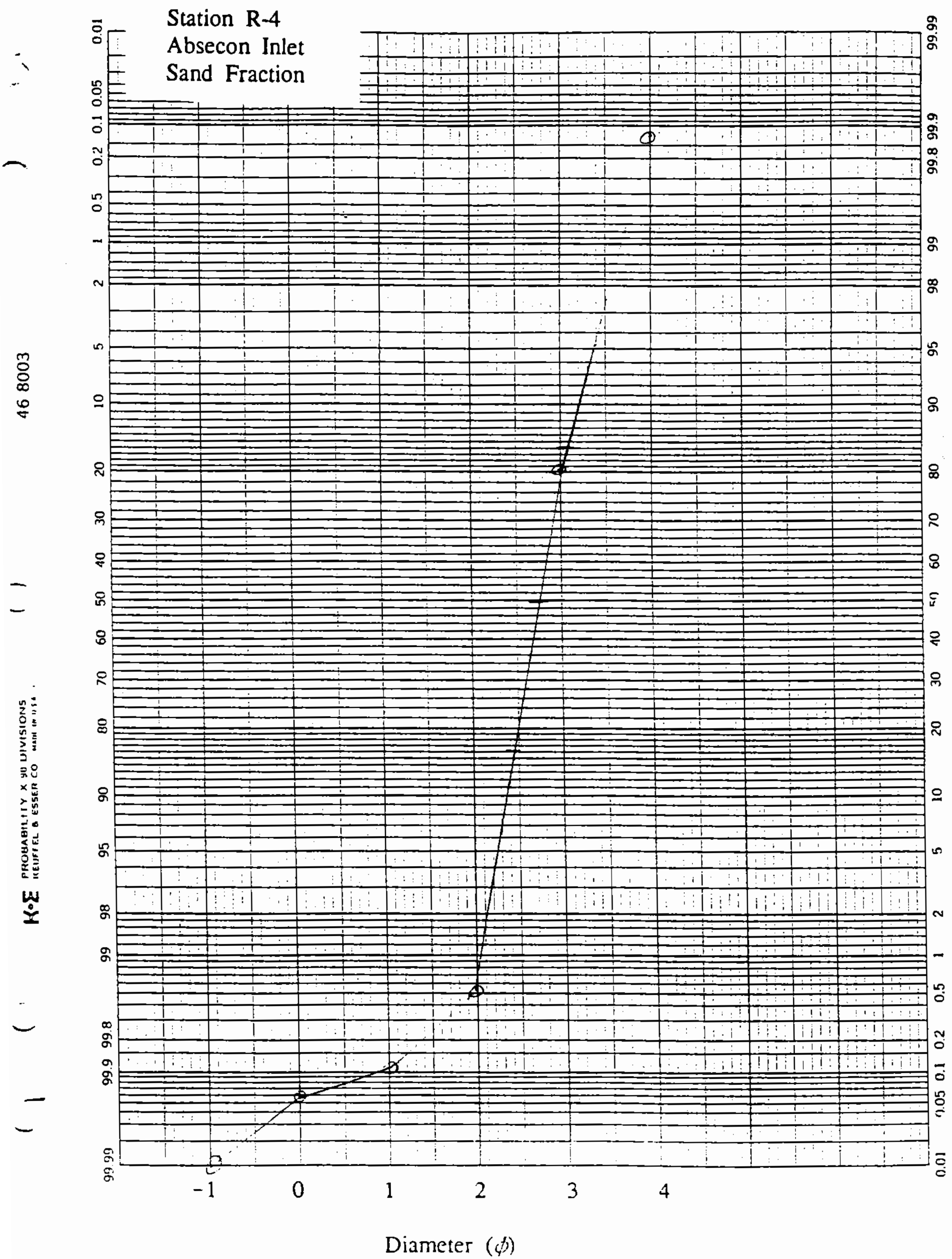
Station R-1
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)
46 8003
K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO MADE IN U.S.A.

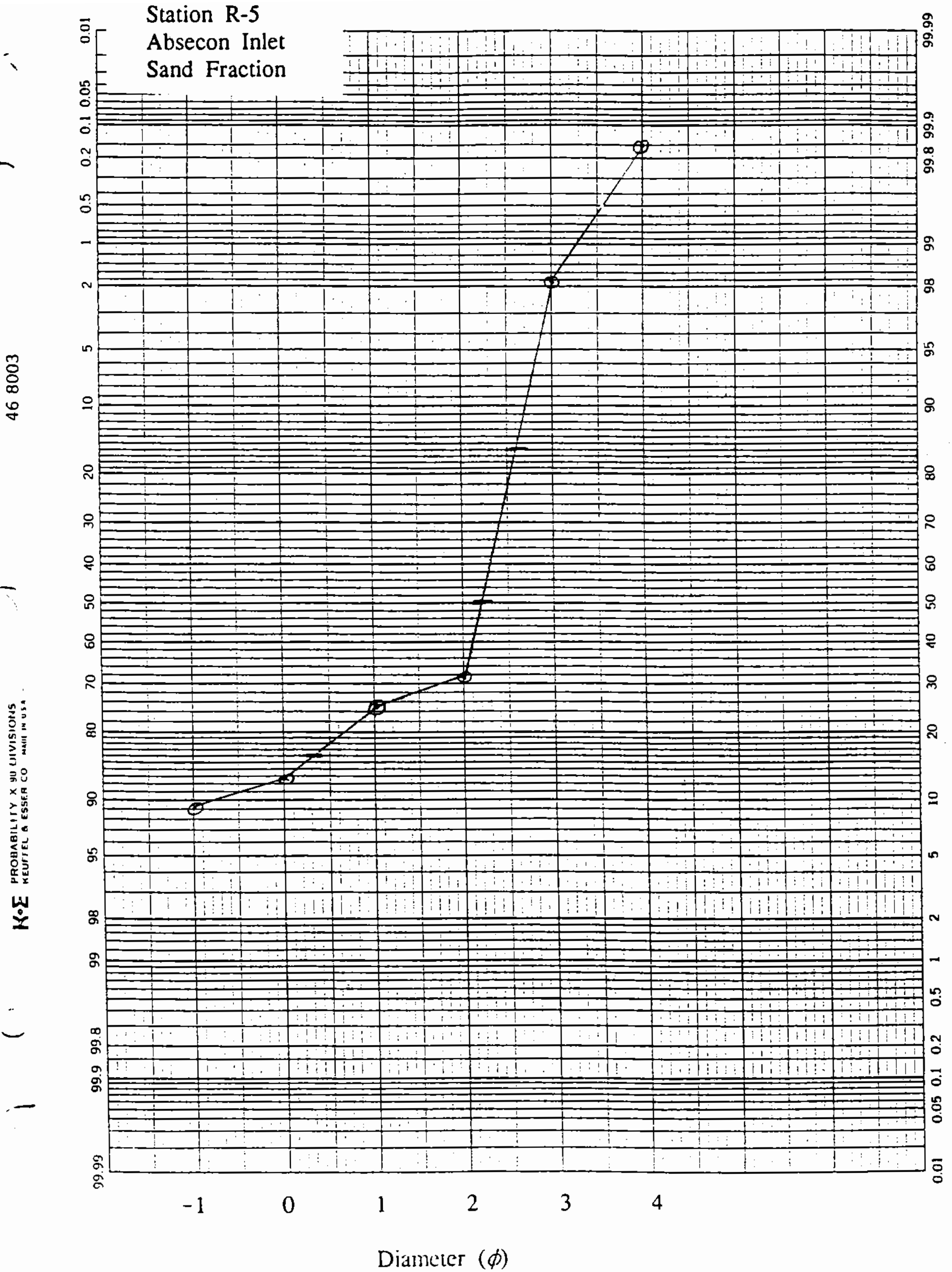


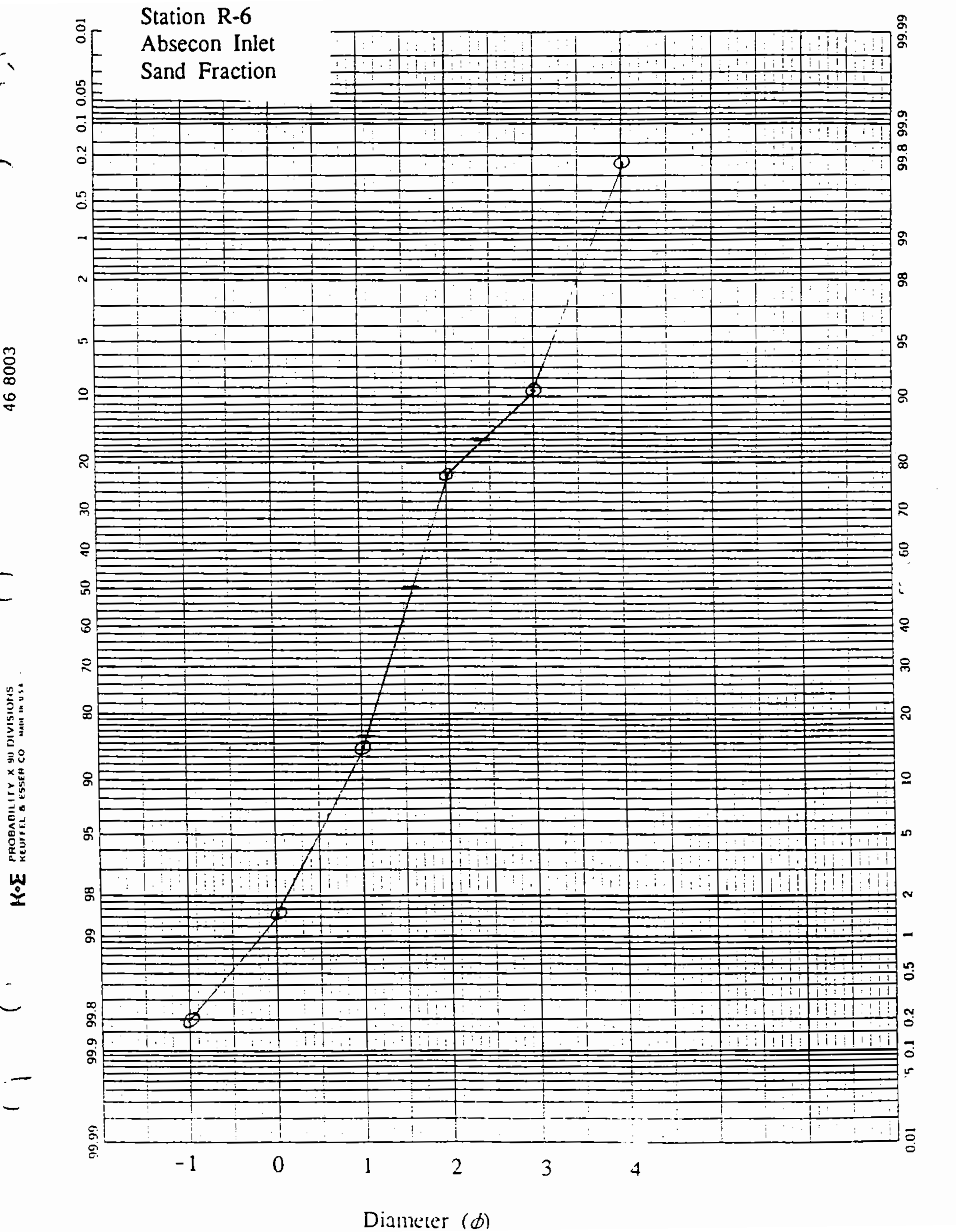
Station R-2
Absecon Inlet
Sand Fraction
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.



Station R-3
Absecon Inlet
Sand Fraction
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
-1 0 1 2 3 4
Diameter (ϕ)

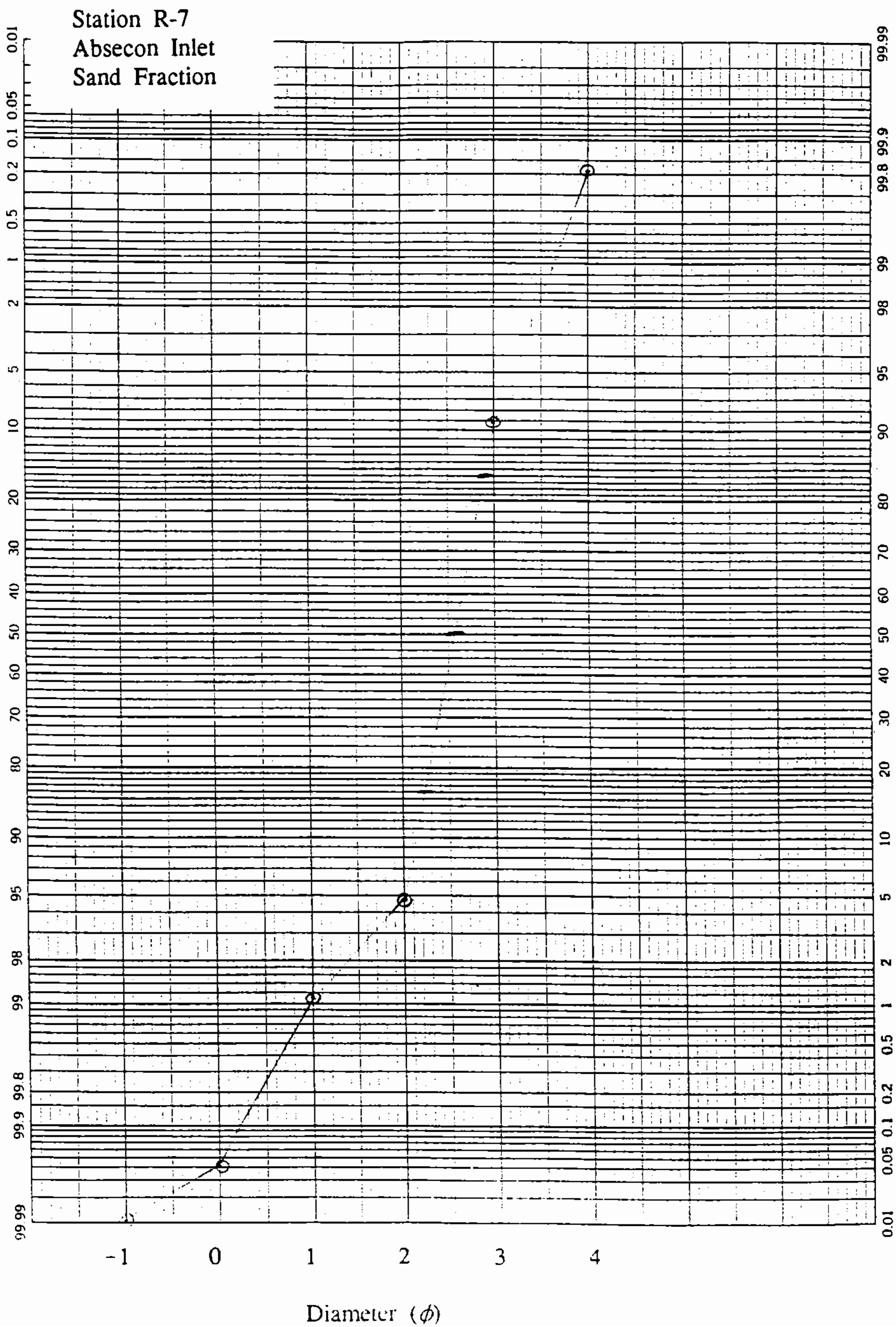

Station R-4
Absecon Inlet
Sand Fraction
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
99.99
99.9
99.8
99
98
95
90
80
70
60
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
-1
0
1
2
3
4
Diameter (ϕ)
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

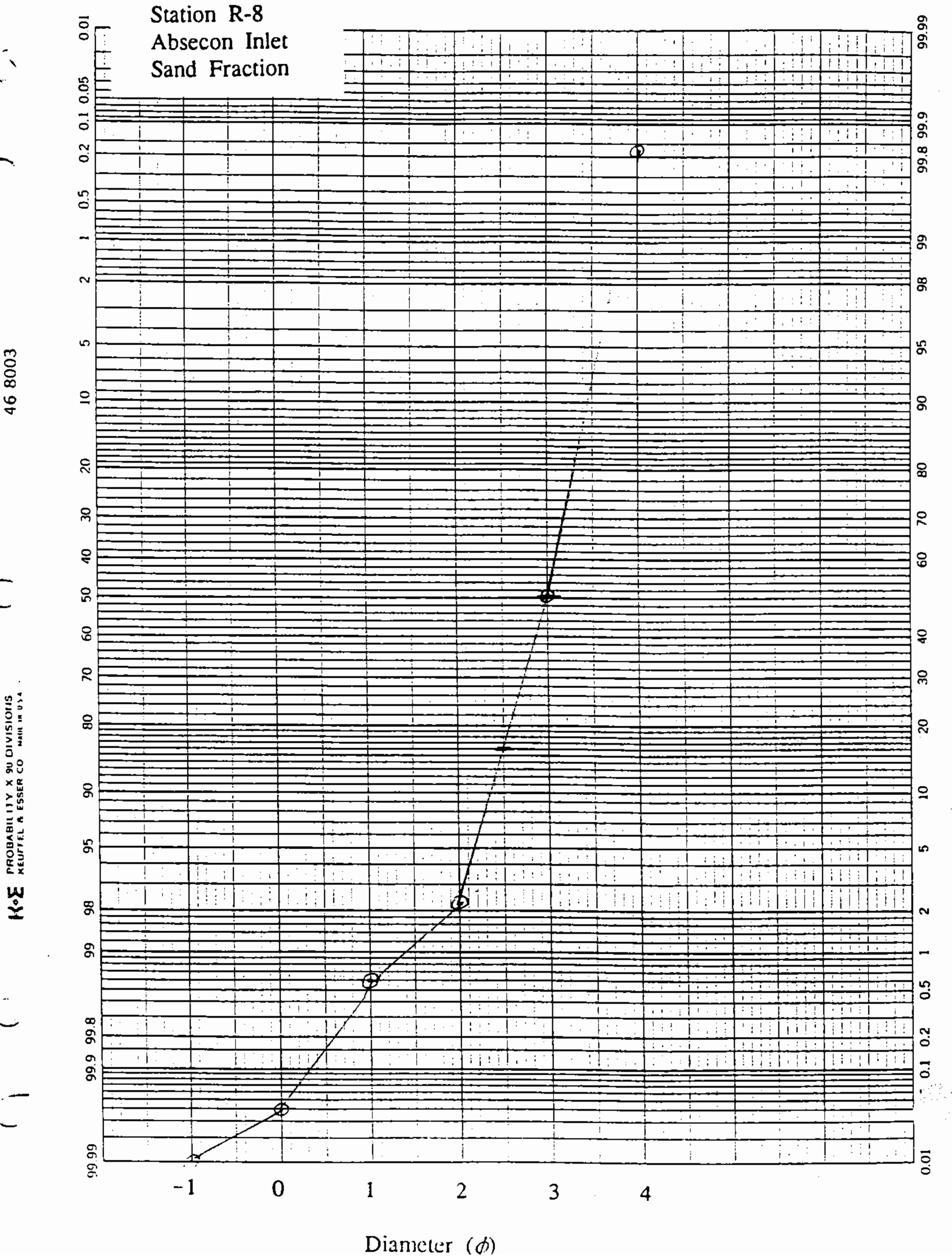

Station R-5
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)


Station R-6
Absecon Inlet
Sand Fraction
46 8003
K-E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)

46 8003

K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN USA





Station R-8
Absecon Inlet
Sand Fraction
46 8003
K•E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
-1
0
1
2
3
4
Diameter (ϕ)

APPENDIX D
MACROFAUNAL DATA

ANNELIDA
- OLIGOCHAETA
  - OLIGOCHAETA (LPIL)
- POLYCHAETA
  - AMPHARETIDAE
    - AMPHARETE (LPIL)
    - AMPHARETE SP.C
    - AMPHARETE SP.D
    - AMPHARETIDAE (LPIL)
  - ARABELLIDAE
    - DRILONEREIS SP.J
  - CAPITELLIDAE
    - CAPITELLA CAPITATA
    - CAPITELLIDAE (LPIL)
    - MEDIOMASTUS (LPIL)
    - MEDIOMASTUS AMBISETA
  - CHAETOPTERIDAE
    - SPIOCHAETOPTERUS OCULATUS
  - CIRRATULIDAE
    - CAULLERIELLA SP.E
    - CAULLERIELLA SP.J
    - CIRRATULIDAE (LPIL)
  - DORVILLEIDAE
    - PAROUGIA CAECA
  - EUNICIDAE
    - EUNICIDAE (LPIL)
  - GLYCERIDAE
    - GLYCERA (LPIL)
    - GLYCERA DIBRANCHIATA
  - HESIONIDAE
    - MICROPHTHALMUS (LPIL)
  - MAGELONIDAE
    - MAGELONA PAPILLICORNIS
  - NEPHTYIDAE
    - NEPHTYIDAE (LPIL)
    - NEPHTYS (LPIL)
    - NEPHTYS BUCERA
    - NEPHTYS PICTA
  - NEREIDAE
    - NEREIDAE (LPIL)
  - ONUPHIDAE
    - DIOPATRA CUPREA
    - ONUPHIDAE (LPIL)
  - OPHELIIDAE
    - OPHELIA DENTICULATA
    - OPHELIIDAE (LPIL)
  - ORBINIIDAE
    - LEITOSCOLOPLOS (LPIL)
    - LEITOSCOLOPLOS FRAGILIS

ORBINIA (LPIL)
ORBINIA SWANI
ORBINIIDAE (LPIL)
PARAONIDAE
PARAONIDAE (LPIL)
PARAONIS FULGENS
PHYLLODOCIDAE
PHYLLODOCE ARENAE
PHYLLODOCIDAE (LPIL)
POLYGORDIIDAE
POLYGORDIUS (LPIL)
SIGALIONIDAE
SIGALION ARENICOLA
SIGALIONIDAE (LPIL)
STHENELAIS (LPIL)
SPIONIDAE
DISPIO UNCINATA
POLYDORA SOCIALIS
SCOLELEPIS (LPIL)
SCOLELEPIS SQUAMATA
SPIONIDAE (LPIL)
SPIOPHANES (LPIL)
SPIOPHANES BOMBYX
STREBLOSPIO BENEDICTI
SYLLIDAE
AUTOLYTUS (LPIL)
PIONOSYLLIS (LPIL)
SYLLIDAE (LPIL)
TEREBELLIDAE
POLYCIRRUS EXIMIUS
ARTHROPODA (CRUSTACEA)
AMPHIPODA
AMPHIPODA (LPIL)
CAPRELLIDAE
CAPRELLA (LPIL)
GAMMARIDAE
GAMMARUS (LPIL)
HAUSTORIIDAE
ACANTHOHAUSTORIUS (LPIL)
ACANTHOHAUSTORIUS MILLSI
BATHYPOREIA (LPIL)
BATHYPOREIA PARKERI
BATHYPOREIA QUODDYENSIS
HAUSTORIIDAE (LPIL)
PARAHAUSTORIUS (LPIL)
PARAHAUSTORIUS ATTENUATUS
PARAHAUSTORIUS LONGIMERUS
PROTOHAUSTORIUS (LPIL)

PROTOHAUSTORIUS SP.B

ISCHYROCERIDAE
CERAPUS TUBULARIS
OEDICEROTIDAE
SYNCHELIDIUM AMERICANUM
PHOXOCEPHALIDAE
PHOXOCEPHALIDAE (LPIL)
RHEPOXYNIUS EPISTOMUS
PONTOGENEIIDAE
PONTOGENEIA INERMIS
CUMACEA
BODOTRIIDAE
MANCOCUMA (LPIL)
DIASTYLIDAE
DIASTYLIS (LPIL)
DECAPODA (NATANTIA)
CRANGONIDAE
CRANGON SEPTEMSPINOSA
CRANGONIDAE (LPIL)
DECAPODA (REPTANTIA)
CANCRIDAE
CANCER IRRORATUS
PAGURIDAE
PAGURUS LONGICARPUS
PAGURUS POLITUS
PORTUNIDAE
OVALIPES OCELLATUS
ISOPODA
CIROLANIDAE
CIROLANIDAE (LPIL)
POLITOLANA POLITA
IDOTEIDAE
CHIRIDOTEA (LPIL)
CHIRIDOTEA CF. TUFTSI
CHIRIDOTEA STENOPS
EDOTEA TRILOBA
SPHAEROMATIDAE
ANCINUS DEPRESSUS
SPHAEROMATIDAE (LPIL)
MYSIDACEA
MYSIDAE
HETEROMYSIS FORMOSA
TANAIDACEA
LEPTOGNATHIDAE
LEPTOGNATHIA (LPIL)
LEPTOGNATHIA CAECA
LEPTOGNATHIDAE (LPIL)
CNIDARIA
CNIDARIA (LPIL)

ECHINODERMATA
ASTEROIDEA
ECHINASTERIDAE
HENRICIA CF. SANGUINOLENTA

ECHINOIDEA
ECHINOIDEA (LPIL)
MOLLUSCA
GASTROPODA
GASTROPODA (LPIL)
NUDIBRANCHIA (LPIL)
CREPIDULIDAE
CREPIDULA FORNICATA
NASSARIIDAE
NASSARIUS TRIVITTATUS
PELECYPODA
MACTRIDAE
SPISULA SOLIDISSIMA
MYTILIDAE
MYTILUS EDULIS
PELECYPODA FAMILY F
PELECYPODA FAMILY F
TELLINIDAE
TELLINA (LPIL)
TELLINA AGILIS
VENERIDAE
MERCENARIA MERCENARIA
RHYNCHOCOELA
RHYNCHOCOELA (LPIL)

Sample Date 94/10/20 Station: 001
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station A

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	REPO	REPP	TOTAL	PERCENT
** CNIDARIA																		
CNIDARIA (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	7	0.44
** RHYNCHOCOELA																		
RHYNCHOCOELA (LPIL)	1	1	1	0	0	3	0	0	0	1	1	0	5	0	0	3	16	1.00
** ANNELIDA																		
POLYCHAETA																		
AMPHARETIDAE																		
AMPHARETIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.06
AMPHARETE SP.C	1	0	0	0	0	0	0	0	5	1	1	0	1	0	0	0	9	0.57
CAPITELLIDAE																		
CAPITELLIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.06
CHAETOPTERIDAE																		
SPIOCHAETOPTERUS OCULATUS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.06
CIRRATULIDAE																		
CIRRATULIDAE (LPIL)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06
CAULLERIELLA SP.J	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06
DORVILLEIDAE																		
PAROUGIA CAECA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.06
MAGELONIDAE																		
MAGELONA PAPILLICORNIS	12	2	3	0	0	15	0	2	0	16	3	0	12	1	0	14	80	5.03
NEPHTYIDAE																		
NEPHTYS BUCERA	1	0	0	1	0	1	0	2	0	2	0	0	0	0	0	0	7	0.44
NEPHTYS PICTA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.06
NEPHTYS (LPIL)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
OPHELIIDAE																		
OPHELIIDAE (LPIL)	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0.13
OPHELIA DENTICULATA	0	0	0	0	0	0	0	0	2	0	0	0	0	5	0	0	7	0.44
ONUPHIDAE																		
DIOPATRA CUPREA	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06
ORBINIIDAE																		
ORBINIIDAE (LPIL)	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0.13
LEITOSCOLOPLOS FRAGILIS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.06
ORBINIA SWANI	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
ORBINIA (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0.13
PARAONIDAE																		
PARAONIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.13
PARAONIS FULGENS	0	0	2	1	0	2	0	0	0	1	1	0	1	1	0	1	10	0.62

-------------Report Continued on Next Page-------------

Sample Date 94/10/20 Station: 001
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station A

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	REPO	REPP	TOTAL	PERCENT
** ANNELIDA																		
POLYCHAETA																		
SPIONIDAE																		
SPIONIDAE (LPIL)	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	7	0.44
SPIOPHANES BOMBYX	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0.19
STREBLOSPIO BENEDICTI	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.06
DISPIO UNCINATA	6	2	0	0	0	2	0	0	0	1	0	0	0	0	0	1	12	0.75
SCOLELEPIS SQUAMATA	0	0	0	8	0	3	6	6	0	0	5	0	0	2	0	2	32	2.01
SYLLIDAE																		
PIONOSYLLIS (LPIL)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06
POLYGORDIIDAE																		
POLYGORDIUS (LPIL)	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	3	0.19
** MOLLUSCA																		
PELECYPODA																		
TELLINIDAE																		
TELLINA (LPIL)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0.13
VENERIDAE																		
MERCENARIA MERCENARIA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
MACTRIDAE																		
SPISULA SOLIDISSIMA	0	1	0	3	6	0	9	2	3	0	1	4	0	0	0	0	29	1.82
PELECYPODA FAMILY F	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	65	4.[illegible]
** ARTHROPODA (CRUSTACEA)																		
ISOPODA																		
IDOTEIDAE																		
EDOTEA TRILOBA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	0.13
CHIRIDOTEA CF. TUFTSI	0	0	1	1	0	0	4	0	2	0	0	0	0	0	0	0	8	0.50
CHIRIDOTEA STENOPS	0	0	0	0	6	0	0	0	0	0	0	0	0	0	1	0	7	0.44
CHIRIDOTEA (LPIL)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0.13
AMPHIPODA																		
OEDICEROTIDAE																		
SYNCHELIDIUM AMERICANUM	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.06
GAMMARIDAE																		
GAMMARUS (LPIL)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06
PHOXOCEPHALIDAE																		
RHEPOXYNIUS EPISTOMUS	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	4	0.25

-------------Report Continued on Next Page-------------

Sample Date 94/10/20 Station: 001
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station A

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	REPO	REPP	TOTAL	PERCENT
** ARTHROPODA (CRUSTACEA)																		
AMPHIPODA																		
HAUSTORIIDAE																		
HAUSTORIIDAE (LPIL)	28	5	2	15	0	1	2	2	0	6	4	4	1	0	3	11	84	5.28
ACANTHOHAUSTORIUS MILLSI	14	22	24	22	3	43	22	2	4	6	12	37	55	0	2	71	339	21.32
ACANTHOHAUSTORIUS (LPIL)	6	7	2	0	0	17	4	0	1	13	4	7	10	0	0	18	89	5.59
PROTOHAUSTORIUS SP.B	68	8	1	0	0	55	0	0	0	116	0	0	111	0	0	63	422	26.54
PARAHAUSTORIUS LONGIMERUS	0	7	4	36	10	4	59	4	0	0	31	48	2	6	9	2	222	13.96
PARAHAUSTORIUS (LPIL)	0	2	0	0	1	0	1	0	0	0	0	4	0	1	0	0	9	0.56
BATHYPOREIA PARKERI	0	6	0	0	1	0	15	0	0	0	12	1	1	0	0	2	38	2.38
BATHYPOREIA QUODDYENSIS	0	0	0	29	0	0	0	0	0	0	0	0	0	0	1	0	30	1.88
BATHYPOREIA (LPIL)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
CUMACEA																		
BODOTRIIDAE																		
MANCOCUMA (LPIL)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
TANAIDACEA																		
LEPTOGNATHIDAE																		
LEPTOGNATHIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.06
LEPTOGNATHIA CAECA	0	0	5	0	0	3	0	0	0	0	0	0	1	0	0	1	10	0.63
DECAPODA (REPTANTIA)																		
PORTUNIDAE																		
OVALIPES OCELLATUS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.06
PAGURIDAE																		
PAGURUS LONGICARPUS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	3	0.19
PAGURUS POLITUS	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0.13
CANCRIDAE																		
CANCER IRRORATUS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.06
** ECHINODERMATA																		
ASTEROIDEA																		
ECHINASTERIDAE																		
HENRICIA CF. SANGUINOLENTA	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.06

-------------Report Continued on Next Page-------------

Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 001
Sample Type: MACROFAUNA

Comments: Station A

NOTE:
LPIL designates the LOWEST PRACTICAL IDENTIFICATION LEVEL

	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	REPO	REPP
Total Individuals per Replicate:	151	65	48	118	28	151	122	20	25	173	75	108	207	19	20	260
Total Taxa per replicate:	15	13	13	11	7	14	9	7	13	18	11	9	18	7	6	21

Total number of taxa for this station = 57

Total number of individuals for this station = 1590

Mean Number Individuals per square meter = 994

PHYLUM	TOTAL # TAXA	% TAXA	TOTAL # INDIVIDUALS	% INDIVIDUALS
ANNELIDA	27	47.3	191	12.1
MOLLUSCA	4	7.0	97	6.1
ARTHROPODA	23	40.3	1278	80.3
ECHINODERMATA	1	1.7	1	.0
MISCELLANEOUS	2	3.5	23	1.5

--------------------Report Continued on Next Page--------------------

Sample Date 94/10/20 Station: 001
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station A

==

The Standard Deviation From the Mean= 74.5

***** FAUNAL CHARACTERISTICS *****

The Species Diversity (Shannon Wiener Index) H°E = 2.40

The Species Evenness (Pielous Evenness Index) J = 0.60

The Species Richness (Margalef's Index) D = 7.61

Report Prepared By: Barry A. Vittor & Associates, Inc.
8060 Cottage Hill Road
Mobile, AL 36695
(205)633-6100

*************** END OF REPORT ***************

Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 002
Sample Type: MACROFAUNA

Comments: Station B

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	TOTAL	PERCENT
** RHYNCHOCOELA																
RHYNCHOCOELA (LPIL)	1	3	0	4	1	1	0	2	2	0	1	2	1	0	18	0.76
** ANNELIDA																
POLYCHAETA																
AMPHARETIDAE																
AMPHARETIDAE (LPIL)	0	12	0	6	0	5	0	8	3	0	0	1	0	0	35	1.47
AMPHARETE SP.C	0	6	0	1	1	3	0	9	0	0	0	0	0	0	20	0.84
AMPHARETE SP.D	0	1	0	1	1	2	0	3	0	0	0	0	0	0	8	0.34
AMPHARETE (LPIL)	0	4	0	0	0	3	0	0	4	0	0	0	0	0	11	0.46
CAPITELLIDAE																
CAPITELLIDAE (LPIL)	0	12	0	1	0	18	0	1	3	0	0	1	0	0	36	1.51
CAPITELLA CAPITATA	0	0	0	0	0	22	0	0	1	0	0	0	0	0	23	0.96
MEDIOMASTUS AMBISETA	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3	0.13
MEDIOMASTUS (LPIL)	0	0	0	0	0	11	0	0	0	0	0	0	0	0	11	0.46
CHAETOPTERIDAE																
SPIOCHAETOPTERUS OCULATUS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
CIRRATULIDAE																
CIRRATULIDAE (LPIL)	0	1	0	0	1	0	0	1	0	0	0	0	0	0	3	0.13
CAULLERIELLA SP.E	1	7	0	2	1	10	3	0	2	0	0	0	0	0	26	1.09
EUNICIDAE																
EUNICIDAE (LPIL)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
GLYCERIDAE																
GLYCERA (LPIL)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.04
MAGELONIDAE																
MAGELONA PAPILLICORNIS	0	34	1	3	35	1	17	14	16	0	0	14	0	0	135	5.66
NEPHTYIDAE																
NEPHTYIDAE (LPIL)	0	7	0	1	0	2	0	0	9	0	0	0	0	0	19	0.80
NEPHTYS BUCERA	0	0	0	0	0	0	0	0	2	0	0	1	0	0	3	0.13
NEPHTYS PICTA	0	2	0	0	1	0	0	0	0	0	1	0	0	0	4	0.17
OPHELIIDAE																
OPHELIA DENTICULATA	1	0	0	0	0	0	1	0	0	0	1	0	0	15	18	0.76
ONUPHIDAE																
ONUPHIDAE (LPIL)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
DIOPATRA CUPREA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.04
ORBINIIDAE																
LEITOSCOLOPLOS FRAGILIS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
LEITOSCOLOPLOS (LPIL)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.04
ORBINIA (LPIL)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.04

-------------Report Continued on Next Page-------------

426

Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 002
Sample Type: MACROFAUNA

Comments: Station B

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	TOTAL	PERCENT
** ANNELIDA																
POLYCHAETA																
PARAONIDAE																
PARAONIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.04
PARAONIS FULGENS	0	4	0	0	1	0	0	0	3	0	0	0	0	0	8	0.34
PHYLLODOCIDAE																
PHYLLODOCIDAE (LPIL)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.04
PHYLLODOCE ARENAE	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
SIGALIONIDAE																
SIGALIONIDAE (LPIL)	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0.08
STHENELAIS (LPIL)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.04
SIGALION ARENICOLA	0	0	3	0	0	0	0	0	0	0	0	2	0	1	6	0.25
SPIONIDAE																
SPIONIDAE (LPIL)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
SPIOPHANES BOMBYX	0	0	0	1	0	0	2	2	0	1	0	2	0	0	8	0.34
STREBLOSPIO BENEDICTI	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0.08
DISPIO UNCINATA	0	2	0	0	0	0	0	1	2	0	0	2	0	0	7	0.29
ARABELLIDAE																
DRILONEREIS SP.J	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.04
POLYGORDIIDAE																
POLYGORDIUS (LPIL)	142	27	9	24	64	0	89	2	19	18	22	262	32	281	991	41.55
OLIGOCHAETA																
OLIGOCHAETA (LPIL)	5	0	0	1	1	12	0	0	0	1	1	1	10	9	41	1.72
** MOLLUSCA																
PELECYPODA																
TELLINIDAE																
TELLINA AGILIS	0	0	0	0	0	0	0	0	0	0	0	0	3	3	6	0.25
TELLINA (LPIL)	3	18	1	0	7	12	5	11	29	0	0	3	0	0	89	3.73
MACTRIDAE																
SPISULA SOLIDISSIMA	3	1	5	4	6	0	1	1	1	1	2	2	0	5	32	1.34
PELECYPODA FAMILY F	12	85	7	0	31	5	22	16	72	7	2	41	6	3	309	12.96
GASTROPODA																
NASSARIIDAE																
NASSARIUS TRIVITTATUS	0	0	0	1	0	0	0	2	1	0	0	0	0	0	4	0.17

-------------Report Continued on Next Page-------------

Sample Date 94/10/20 Station: 002
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station 8

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	TOTAL	PERCENT
** ARTHROPODA (CRUSTACEA)																
ISOPODA																
IDOTEIDAE																
EDOTEA TRILOBA	1	0	0	0	0	3	0	1	0	0	0	0	0	0	5	0.21
CHIRIDOTEA CF. TUFTSI	0	0	0	0	7	0	9	0	0	0	0	19	0	0	35	1.47
CIROLANIDAE																
CIROLANIDAE (LPIL)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
POLITOLANA POLITA	1	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0.13
SPHAEROMATIDAE																
SPHAEROMATIDAE (LPIL)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.04
ANCINUS DEPRESSUS	0	4	0	0	2	0	0	4	4	0	0	0	0	0	14	0.59
AMPHIPODA																
AMPHIPODA (LPIL)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
OEDICEROTIDAE																
SYNCHELIDIUM AMERICANUM	0	1	0	2	0	0	0	2	1	0	0	0	0	0	6	0.25
GAMMARIDAE																
GAMMARUS (LPIL)	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0.08
PHOXOCEPHALIDAE																
PHOXOCEPHALIDAE (LPIL)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
RHEPOXYNIUS EPISTOMUS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.04
HAUSTORIIDAE																
HAUSTORIIDAE (LPIL)	0	8	0	0	2	0	2	1	2	0	0	9	1	0	25	1.05
ACANTHOHAUSTORIUS MILLSI	0	6	0	0	4	1	2	5	6	0	0	4	0	0	28	1.17
ACANTHOHAUSTORIUS (LPIL)	0	10	0	7	7	0	0	0	5	0	0	0	0	0	29	1.22
PROTOHAUSTORIUS SP.B	0	87	0	61	26	0	0	41	57	0	1	2	1	1	277	11.61
PROTOHAUSTORIUS (LPIL)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.04
PARAHAUSTORIUS LONGIMERUS	1	0	3	0	0	0	0	0	0	2	2	4	4	0	16	0.67
PARAHAUSTORIUS ATTENUATUS	0	0	0	0	0	0	2	0	0	1	1	6	1	1	12	0.50
PARAHAUSTORIUS (LPIL)	0	0	0	0	0	0	0	0	0	0	0	2	1	0	3	0.13
ISCHYROCERIDAE																
CERAPUS TUBULARIS	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.04
PONTOGENEIIDAE																
PONTOGENEIA INERMIS	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0.13
CUMACEA																
DIASTYLIDAE																
DIASTYLIS (LPIL)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.04

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Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 002
Sample Type: MACROFAUNA

Comments: Station B

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN	TOTAL	PERCENT
** ARTHROPODA (CRUSTACEA)																
TANAIDACEA																
LEPTOGNATHIDAE																
LEPTOGNATHIDAE (LPIL)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.04
LEPTOGNATHIA CAECA	3	1	1	0	0	0	2	0	0	1	1	3	2	1	15	0.63
LEPTOGNATHIA (LPIL)	1	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0.13
DECAPODA (NATANTIA)																
CRANGONIDAE																
CRANGON SEPTEMSPINOSA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.04
DECAPODA (REPTANTIA)																
PORTUNIDAE																
OVALIPES OCELLATUS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.04
PAGURIDAE																
PAGURUS LONGICARPUS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.04
PAGURUS POLITUS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.04
** ECHINODERMATA																
ECHINOIDEA																
ECHINOIDEA (LPIL)	0	0	0	0	1	0	0	0	0	1	1	1	0	0	4	0.17

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Sample Date 94/10/20 Station: 002
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station B

NOTE:
LPIL designates the LOWEST PRACTICAL IDENTIFICATION LEVEL

	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	REPI	REPJ	REPK	REPL	REPM	REPN
Total Individuals per Replicate:	179	348	32	123	202	120	159	128	247	33	36	391	63	324
Total Taxa per replicate:	17	29	10	19	22	23	15	21	25	9	12	26	12	14

Total number of taxa for this station = 73

Total number of individuals for this station = 2385

Mean Number Individuals per square meter = 1704

PHYLUM	TOTAL # TAXA	% TAXA	TOTAL # INDIVIDUALS	% INDIVIDUALS
ANNELIDA	37	50.6	1434	60.1
MOLLUSCA	5	6.8	440	18.4
ARTHROPODA	29	39.7	489	20.5
ECHINODERMATA	1	1.3	4	.1
MISCELLANEOUS	1	1.3	18	.7

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Sample Date 94/10/20 Station: 002
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station B

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The Standard Deviation From the Mean= 119.3

***** FAUNAL CHARACTERISTICS *****

The Species Diversity (Shannon Wiener Index) H°E = 2.38

The Species Evenness (Pielous Evenness Index) J= .55

The Species Richness (Margalef's Index) D= 9.26

Report Prepared By: Barry A. Vittor & Associates, Inc.
8060 Cottage Hill Road
Mobile, AL 36695
(205)633-6100

*************** END OF REPORT ***************

Sample Date 94/10/20 Station: 003
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station R

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	TOTAL	PERCENT
** RHYNCHOCOELA										
RHYNCHOCOELA (LPIL)	3	5	0	2	5	1	2	0	18	1.47
** ANNELIDA										
POLYCHAETA										
AMPHARETIDAE										
AMPHARETIDAE (LPIL)	0	0	1	1	0	0	0	2	4	0.33
AMPHARETE SP.C	0	0	0	0	3	0	0	0	3	0.24
AMPHARETE SP.D	0	0	0	0	0	0	0	1	1	0.08
CAPITELLIDAE										
CAPITELLIDAE (LPIL)	0	1	0	0	0	5	0	0	6	0.49
MEDIOMASTUS AMBISETA	0	0	0	0	0	8	0	0	8	0.65
CIRRATULIDAE										
CAULLERIELLA SP.E	0	0	0	0	1	4	0	0	5	0.41
DORVILLEIDAE										
PAROUGIA CAECA	0	1	0	0	5	0	0	0	6	0.49
GLYCERIDAE										
GLYCERA DIBRANCHIATA	0	0	0	0	0	1	0	1	2	0.16
HESIONIDAE										
MICROPHTHALMUS (LPIL)	0	0	0	0	3	0	0	0	3	0.24
MAGELONIDAE										
MAGELONA PAPILLICORNIS	7	23	18	13	0	1	21	9	92	7.52
NEPHTYIDAE										
NEPHTYIDAE (LPIL)	0	0	1	0	0	0	0	1	2	0.16
NEPHTYS BUCERA	1	0	0	0	0	0	0	0	1	0.08
NEPHTYS PICTA	0	0	0	0	0	0	0	1	1	0.08
NEPHTYS (LPIL)	0	0	3	0	0	0	0	0	3	0.24
NEREIDAE										
NEREIDAE (LPIL)	0	0	0	0	1	0	0	0	1	0.08
OPHELIIDAE										
OPHELIA DENTICULATA	0	0	0	0	48	0	0	0	48	3.92
ONUPHIDAE										
ONUPHIDAE (LPIL)	0	0	1	0	0	0	0	0	1	0.08
ORBINIIDAE										
ORBINIIDAE (LPIL)	0	0	0	0	0	0	0	1	1	0.08
ORBINIA (LPIL)	0	1	0	1	0	0	0	0	2	0.16
PARAONIDAE										
PARAONIDAE (LPIL)	0	0	0	0	0	0	0	1	1	0.08
PARAONIS FULGENS	1	1	1	0	0	1	2	0	6	0.49

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Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 003
Sample Type: MACROFAUNA

Comments: Station R

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	TOTAL	PERCENT
** ANNELIDA										
POLYCHAETA										
SPIONIDAE										
SPIONIDAE (LPIL)	0	1	0	0	0	0	0	1	2	0.16
POLYDORA SOCIALIS	0	0	0	0	24	0	0	0	24	1.96
SPIOPHANES BOMBYX	0	2	0	0	0	0	0	1	3	0.24
SPIOPHANES (LPIL)	0	0	3	0	0	0	0	0	3	0.24
DISPIO UNCINATA	1	8	0	0	0	0	6	1	16	1.31
SCOLELEPIS (LPIL)	0	0	0	1	0	0	0	1	2	0.16
SYLLIDAE										
SYLLIDAE (LPIL)	0	0	0	0	1	0	0	0	1	0.08
AUTOLYTUS (LPIL)	0	0	0	0	6	0	0	0	6	0.49
TEREBELLIDAE										
POLYCIRRUS EXIMIUS	0	0	0	0	1	0	0	0	1	0.08
ARABELLIDAE										
DRILONEREIS SP.J	0	1	1	0	0	0	0	0	2	0.16
POLYGORDIIDAE										
POLYGORDIUS (LPIL)	0	0	2	0	5	33	38	3	81	6.62
OLIGOCHAETA										
OLIGOCHAETA (LPIL)	0	0	0	0	2	0	0	0	2	0.16
** MOLLUSCA										
PELECYPODA										
MYTILIDAE										
MYTILUS EDULIS	1	0	1	0	3	0	0	0	5	0.41
TELLINIDAE										
TELLINA AGILIS	2	1	2	0	2	2	2	5	16	1.31
MACTRIDAE										
SPISULA SOLIDISSIMA	0	0	3	1	2	0	0	0	6	0.49
PELECYPODA FAMILY F	22	10	27	31	0	0	9	73	172	14.05
GASTROPODA										
GASTROPODA (LPIL)	0	0	0	0	0	0	1	0	1	0.08
NUDIBRANCHIA (LPIL)	0	0	0	0	9	0	0	0	9	0.73
NASSARIIDAE										
NASSARIUS TRIVITTATUS	0	1	1	0	0	0	1	0	3	0.24

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Sample Date 94/10/20 Station: 003
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station R

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	TOTAL	PERCENT
** MOLLUSCA										
GASTROPODA										
CREPIDULIDAE										
CREPIDULA FORNICATA	0	0	0	0	24	0	0	0	24	1.96
** ARTHROPODA (CRUSTACEA)										
ISOPODA										
IDOTEIDAE										
CHIRIDOTEA CF. TUFTSI	0	0	2	0	0	0	2	0	4	0.33
CIROLANIDAE										
POLITOLANA POLITA	0	0	0	0	0	1	0	0	1	0.08
SPHAEROMATIDAE										
ANCINUS DEPRESSUS	0	0	0	0	0	0	0	1	1	0.08
AMPHIPODA										
OEDICEROTIDAE										
SYNCHELIDIUM AMERICANUM	0	0	0	0	0	0	0	1	1	0.08
CAPRELLIDAE										
CAPRELLA (LPIL)	0	0	0	0	1	0	0	0	1	0.08
PHOXOCEPHALIDAE										
RHEPOXYNIUS EPISTOMUS	0	1	5	0	4	0	0	0	10	0.82
HAUSTORIIDAE										
HAUSTORIIDAE (LPIL)	2	4	8	7	0	0	0	0	21	1.72
ACANTHOHAUSTORIUS MILLSI	49	30	15	32	0	0	10	5	141	11.52
ACANTHOHAUSTORIUS (LPIL)	7	14	6	17	0	0	0	0	44	3.60
PROTOHAUSTORIUS SP.B	23	131	98	17	0	0	1	97	367	29.98
PROTOHAUSTORIUS (LPIL)	0	0	0	0	0	0	1	0	1	0.08
PARAHAUSTORIUS LONGIMERUS	5	1	0	4	0	0	2	0	12	0.98
PARAHAUSTORIUS ATTENUATUS	0	0	0	0	0	0	5	0	5	0.41
BATHYPOREIA PARKERI	0	0	0	2	0	0	0	0	2	0.16
BATHYPOREIA QUOODYENSIS	0	0	0	2	0	0	0	0	2	0.16
BATHYPOREIA (LPIL)	1	0	0	0	0	0	0	0	1	0.08
MYSIDACEA										
MYSIDAE										
HETEROMYSIS FORMOSA	0	0	0	0	3	0	0	0	3	0.24
TANAIDACEA										
LEPTOGNATHIDAE										
LEPTOGNATHIDAE (LPIL)	2	0	0	0	0	0	0	0	2	0.16

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Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 003
Sample Type: MACROFAUNA

Comments: Station R

TAXON	REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH	TOTAL	PERCENT
** ARTHROPODA (CRUSTACEA)										
TANAIDACEA										
LEPTOGNATHIDAE										
LEPTOGNATHIA CAECA	1	2	0	0	1	0	3	0	7	0.57
DECAPODA (NATANTIA)										
CRANGONIDAE										
CRANGONIDAE (LPIL)	0	0	0	0	0	1	0	0	1	0.08
DECAPODA (REPTANTIA)										
PAGURIDAE										
PAGURUS LONGICARPUS	0	0	0	1	1	0	0	0	2	0.16
CANCRIDAE										
CANCER IRRORATUS	0	0	0	0	1	0	0	0	1	0.08

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Sample Date 94/10/20 Station: 003
Sample Size 0.1000 SQ. M Sample Type: MACROFAUNA

Comments: Station R

NOTE:
LPIL designates the LOWEST PRACTICAL IDENTIFICATION LEVEL

REPA	REPB	REPC	REPD	REPE	REPF	REPG	REPH
Total Individuals per Replicate:							
128	239	199	132	156	58	106	206
Total Taxa per replicate:							
16	20	20	15	24	11	16	19

Total number of taxa for this station = 64

Total number of individuals for this station = 1224

Mean Number Individuals per square meter = 1530

PHYLUM	TOTAL # TAXA	% TAXA	TOTAL # INDIVIDUALS	% INDIVIDUALS
ANNELIDA	33	51.5	340	27.7
MOLLUSCA	8	12.5	236	19.2
ARTHROPODA	22	34.3	630	51.4
ECHINODERMATA	0	.0	0	.0
MISCELLANEOUS	1	1.5	18	1.4

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Sample Date 94/10/20
Sample Size 0.1000 SQ. M

Station: 003
Sample Type: MACROFAUNA

Comments: Station R

==

The Standard Deviation From the Mean= 59.3

***** FAUNAL CHARACTERISTICS *****

The Species Diversity (Shannon Wiener Index) H°E = 2.65

The Species Evenness (Pielous Evenness Index) J= .64

The Species Richness (Margalef's Index) D= 8.85

Report Prepared By: Barry A. Vittor & Associates, Inc.
8060 Cottage Hill Road
Mobile, AL 36695
(205)633-6100

*************** END OF REPORT ***************

APPENDIX E
LIST OF SUBCONTRACTORS

Survey Vessel
TG&B Marine Services
639 Boxberry Hill Road
Falmouth, MA 02536
(508) 759-0300
Mark Avakian—Captain

Chief Scientist, Field Support
Ocean's Taxonomic Services
938 Head of the Bay Road
Plymouth, MA 02360
(508) 759-7668
Mr. Russell Winchell

Macrofaunal Analysis
Barry Vittor and Associates
8060 Cottage Hill Road
Mobile, AL
(205) 633-6100
Dr. Barry Vittor

Sediment Grain-Size Analysis
GEO/Plan Associates
30 Mann Street
Hingham, MA 02043
(617) 740-1340
Dr. Peter Rosen

Sediment TOC Analysis
Global Geochemistry Corporation
6919 Eton Avenue
Canoga Park, CA 91303
(818(992-4103
Mr. Jim Drury

APPENDIX F
SCOPE OF WORK

STATEMENT OF WORK
TCN: 95-001

SCIENTIFIC SERVICES PROGRAM
Short Term Analysis Service (STAS)
Statement of Work

1. Title: Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey: Benthic Animal Assessment of Potential Borrow Source.

2. General: The benthic animal assessment for the Brigantine Inlet area is part of a broader study covering approximately 15 miles of Atlantic Ocean coast in Southern New Jersey, and includes two islands, Brigantine and Absecon Islands, which are located in Atlantic County.

The purpose of this study is to investigate shore protection and hurricane damage problems and to consider potential solutions. The feasibility study is being conducted through a series of two staggered interim studies. The first interim study and the investigation area for this Statement of Work includes Absecon Island which contains the four communities of Atlantic City, Ventnor, Margate, and Longport. This interim includes substantial data acquisition and analysis to define existing coastal processes and conditions along the entire coast. The second interim, which is not covered in this Statement of Work, will include the island of Brigantine which is bounded by Brigantine Inlet to the north and Absecon Inlet to the south, and contains the City of Brigantine and the North Brigantine State Natural Area. Both Islands front the Atlantic Ocean on their eastern boundaries and have extensive coastal and estuarine wetlands on their western boundaries.

A critical component of this feasibility study is the evaluation and selection of an offshore sand borrow source for beach nourishment. Several issues have been identified during the Reconnaissance Study that need to be addressed such as the disruption of commercially/recreationally and ecologically important benthic communities within the borrow source, and the generation of baseline benthic data for this area in order to determine potential impacts to these benthic habitats.

Due to the dynamic nature of benthic biological communities and the relatively long time-frame of the interim studies, only the borrow sources for the first interim feasibility study and its immediate vicinity will be investigated under this statement of work. The potential borrow source areas identified for this interim study is located immediately offshore of Atlantic City (see Figures 1 and 2).

The Philadelphia District Environmental Resources Branch does not have the necessary in-house capability to perform the tasks specified in the Statement of Work, and no other known government laboratory or center has the capability to perform the work.

3. Objectives: The purpose of the benthic study is to evaluate the benthic macroinvertebrate community within the proposed borrow areas, and to offer a comparison with the benthic communities outside of the proposed borrow areas. The contractor should establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow areas and in two distinct control areas immediately outside of the proposed borrow areas. The contractor will also identify the presence of any commercial and/or recreational benthic macroinvertebrates within the proposed borrow areas.

4. Specific Tasks: The contract must provide a demonstrated capability to provide all facilities, equipment, supplies, and personnel necessary to perform the benthic assessment study with qualitative and quantitative interpretation and report generation described in the tasks below. The work is to be performed by the contractor independent of government direction, supervision, and control. This request represents non-personal services and is not in violation of the personal services policy set forth in Paragraph 37.104 of the Federal Acquisition Regulation.

Benthic sampling stations shall be distributed throughout the proposed borrow areas offshore of Atlantic City. Several sampling stations will be located outside of these proposed borrow areas and will act as "control" areas. Field sampling shall be conducted between the period 19 September through 19 October 1994. Each sample shall contain enough grabs to cover an area of at least 0.1 m^2 of the bottom. Particle size distribution analyses shall be conducted at each sample station. Samples shall be obtained by using a benthic grab, dredge, or similar device and preserved with formalin and rose bengal stain. The samples shall be sorted into the major taxonomic groups (Phylum Annelida, Mollusca, etc.). Each major taxonomic group shall be analyzed for organism abundance, biomass density, and size distribution. Taxonomic identifications shall be conducted on each sample to the lowest taxonomic unit possible (genus or species). Benthic community structure and diversity, commercial species and opportunistic species information, and benthic community similarity/dissimilarity shall be analyzed on each sample. This information shall be presented in a type-written scientific report including sections describing the objective, methodologies, results, discussion, and conclusions. The results and analyses shall include but not be limited to graphical, tabular, and chart presentations of the data and findings. The conclusions section shall evaluate the potential recovery of the benthic community based on the species found. Original data sheets shall be provided in the appendices of the report.

Specific Tasks to Be Performed:

Task I: SAMPLING

A. Sample Station Locations

1. Suitable sand borrow sources are located

immediately offshore of Atlantic City. The borrow areas are defined in New Jersey State Plane coordinates (National Geodetic Survey) and longitude/latitude coordinates and are enclosed with this Statement of Work. The total area of the two borrow sources being considered is estimated to be approximately 488 acres. The borrow areas will be divided into thirty (30) equal cells of approximately 16.3 acres each. The thirty cells shall contain 1 randomly selected sample station within each. If, due to the configuration of the borrow areas, it is not possible to divide the areas into equal cells, thirty random sample areas may be chosen within the two borrow sources. All proposed sample areas must be mapped and approved by the Corps representative prior to conducting the sampling effort

2. Eight "control" samples shall be taken outside the boundary of the borrow areas but within an area (or areas) exhibiting similar depth and substrate characteristics. The contractor will consult with the government point of contact to identify 8 control sample sites outside of previously disturbed areas.

3. Each sample shall have one (1) sub-core sample utilized for sediment grain size analysis.

4. Each sample station location shall be predetermined and plotted on a U.S.C.G. or NOAA Navigation Map. This map shall be presented in the report. LORAN or GPS navigation systems shall be utilized on the boat for accurate verification of sample locations. The system utilized must be identified in the report.

B. Field Records

1. The following information shall be recorded at the time of each sample collection:

- time and date
- time of latest high or low tide at closest tide station
- physical and chemical factors such as depth, temperature, pH, dissolved oxygen, and salinity of the water column directly above the benthic community shall be measured at each station where all samples are designated. All stations shall have depth measurements.

2. The following information shall be recorded inside and on each sample jar on separate labels:

- station number
- sample number
- date

C. Sample Collection

1. A benthic grab device such as a Smith-McIntyre grab, Peterson Dredge, Van-Veen Dredge or similar device shall be used for sampling the benthic community. The appropriate number of grabs shall be conducted to attain a sample area equivalent to 0.1 square meter.

*Note: The number of individual grabs to attain a sampling area of 0.1 square meters is equal to one sample.

2. All samples shall be gently rinsed and washed through a 0.5 mm sieve (a 1.0 mm sieve may be used to remove larger animals and debris prior to using the 0.5 mm sieve.) Large debris shall be picked and removed from the sample. Samples shall be labeled, placed in separate jars and preserved in a 50% formalin solution containing rose bengal stain. The sediment samples shall be placed in its entirety and unpreserved in a sample container or plastic bag for laboratory particle size analysis.

3. Physical and chemical factors shall be measured and recorded concurrently with the biological sampling at the designated stations. These factors shall include depth, temperature, pH, dissolved oxygen, and salinity.

**All sampling devices and equipment shall be obtained by the contractor. A list of suggested equipment is provided in Appendix A.

TASK II: LABORATORY ANALYSIS

A. Species Identification

1. Samples shall be washed with water and placed in water during laboratory analysis. Animals shall be picked from the detritus. Animals from each sample shall be sorted into their respective major taxonomic groups (Phyla).

2. All intact macrofaunal species and body fragments identifiable to species level will be removed from each sample for processing. Dead bivalves (hinged shells and intact single valves) of commercial value will also be removed from the sample debris.

3. Organisms from each major taxonomic group shall be counted separately. Record the number of individuals within each taxonomic unit for each sample.

4. The animals in each taxonomic unit shall be estimated for approximate length (greater than or equal to; or less than 2 cm in length). If individuals are fragmented, record based on the approximate length of the whole animal.

5. Biomass determinations shall be completed on each sample within the same day to avoid sample degradation.

6. Store final samples in 70% ethanol, with one vial or jar per sample. The contractor shall retain samples for a period of 3 months after the final report is issued. A reference collection of each taxonomic unit shall be provided to the Philadelphia District Corps of Engineers after this period. The remaining samples shall become property of the contractor and utilized at the discretion of the contractor.

5. Reporting Requirements: TASK III: A publishable report shall be prepared presenting the data, analysis, and discussions of the benthic sampling study.

A. Data Presentation

1. The following information shall be presented in the report: size distribution of organisms, organism dominance within sample and within borrow areas, taxonomic distribution, overall diversity of organisms in each borrow area, wet weight and biomass of major taxonomic groups, and sediment grain size analysis at each station. Additional information regarding recreational/commercial species and opportunistic species shall be presented.

2. All data shall be presented in, but not be limited to, graphical and tabular forms. Data tables per station will be presented in Appendices and include the following:

- taxa
- number of individuals per taxon by size group (<2 cm and ≥ 2 cm) and total count
- total number of taxa per station
- total number of individuals per station
- Shannon-Weiner Diversity
- Simpson's Dominance Index
- Species Richness
- Evenness

Data tables summarizing environmental parameters shall include the following:

- sediment as defined by mean grain size, standard deviation, sorting descriptive, and percent composition by sediment classification
- salinity (ppt)
- pH
- water temperature (C)
- DO (mg/L)

B. Statistical Analysis

1. Statistical analysis shall include but not be limited to abundance and/or densities (i.e. biomass/unit area, numbers of organisms/unit area etc.), and benthic community structure and diversity (i.e. Shannon-Weiner Diversity Index, Simpson's Dominance Index, and Bray-Curtis Similarity Measure and Cluster Analysis).

2. Sediment data will be analyzed for mean grain size and standard deviation using formulas provided in the Shore Protection Manual (U.S. Army Corps of Engineers, 1984) for the graphic mean (cumulative grain size distribution). Grain size distribution of sediments should also be described qualitatively as well sorted or poorly sorted (Folk, 1974) depending on how close all particle sizes are to the typical size (mean).

3. Statistical data shall be presented in graphical or tabular form to provide easy comparisons between stations.

<u>Report Text:</u> The Corps will provide, upon contractor's request, readily available district project information.

1. The report shall include written discussions of, but not be limited to, the following sections:

- purpose/objective of the study
- methodology
- results
- discussion
- conclusions

The discussion and/or conclusions sections shall include information resulting from a survey of appropriate literature/reports to address 1) grain size compatibility with the beach nourishment site, 2) the potential for impacts to threatened and endangered species as well as marine mammals, 3) the potential for impacts to nearby sessile epifaunal communities by resuspension, 4) the relative importance of organisms found in borrow areas compared to other coastal locations, 5) species dominance within the borrow areas, 6) and the potential for impacts to commercial or sport fisheries.

C. Appendices

1. All figures, tables, maps, and charts shall be presented in the appendices, as appropriate.

2. Appendices shall include original (dated) data sheets.

3. Appendices shall also include a copy of the names of all subcontractors utilized and their addresses.

D. Miscellaneous

1. If the report has been written by someone other than the contract principal investigator, the cover and title page of the publishable report shall bear the inscription: Prepared Under the Supervision of (Name), Principal Investigator. The principal investigator is required to sign the original document. In addition, the principal investigator must at least prepare a forward describing the overall research context of the report, the significance of the work and any other related background circumstances relating to the manner in which the work was undertaken.

2. The TITLE PAGE of the report shall include the date (month and year) the report was submitted, the project name, the author organization and/or client, and contract number.

3. A TABLE OF CONTENTS, including a list of all Figures and Tables shall be presented in the report.

4. PAGE SIZE AND FORMAT. The report shall be produced on 8 1/2 x 11" paper, single-spaced, with double spacing between paragraphs. Figures shall be 8 1/2 x 11" or folded 11 x 17" format sheet size. All text pages (including appendices) shall be consecutively numbered. Text print quality must be at least letter quality.

5. All references shall be properly cited in a bibliography at the end of the report text.

Submittals and Schedules:

A. Field sampling shall commence on or after 19 September 1994, and shall be completed no later than 19 October 1994.

B. The Contractor shall provide 3 copies of the draft report to the Philadelphia District U.S. Army Corps of Engineers, 100 Penn Square East, Philadelphia, Pennsylvania 19107-3390. POC: Beth Brandreth, Environmental Resources Branch (215-656-6558) within 50 calendar days from the completion of the sample collection.

C. The Corps will provide comments to the contractor within 21 calendar days of receipt of the draft report. The contractor is responsible for incorporating any changes to the draft document.

D. The contractor shall provide 5 bound copies and 1 unbound, reproducible original copy of the final report to the Philadelphia District Corps of Engineers within 21 calendar days of receipt of the review comments on the draft report.

E. All tasks described under this scope shall be completed by 30 January 1995.

One copy of the final report shall be submitted to Battelle, RTP.

6. Qualification Requirements: The contractor must have a demonstrated ability to develop and perform biological field sampling in a marine system at statistically representative locations using benthic grab sampling equipment and to provide statistical analytical review and discussion of the results. It is the responsibility of the contractor (or subcontractors) to furnish any facilities (equipment, laboratory support, etc) needed to perform the effort.

7. Place, Period of Performance, and Travel:

a. The desired inclusive performance period will be from ~~19~~ 10 October ~~September~~ 1994 through 30 January 1995.

b. The contractor should conduct all field work within 7 days, weather permitting, laboratory analysis and interpretation within 43 days and report preparation within 22 days.

Research Technician - 14 days: two days travel-Absecon Inlet
Research Scientist - 22 days: two days travel-Absecon Inlet
Laboratory Technician - 43 days
Scientific Writer - 4 days
Clerical Assistant - 3 days

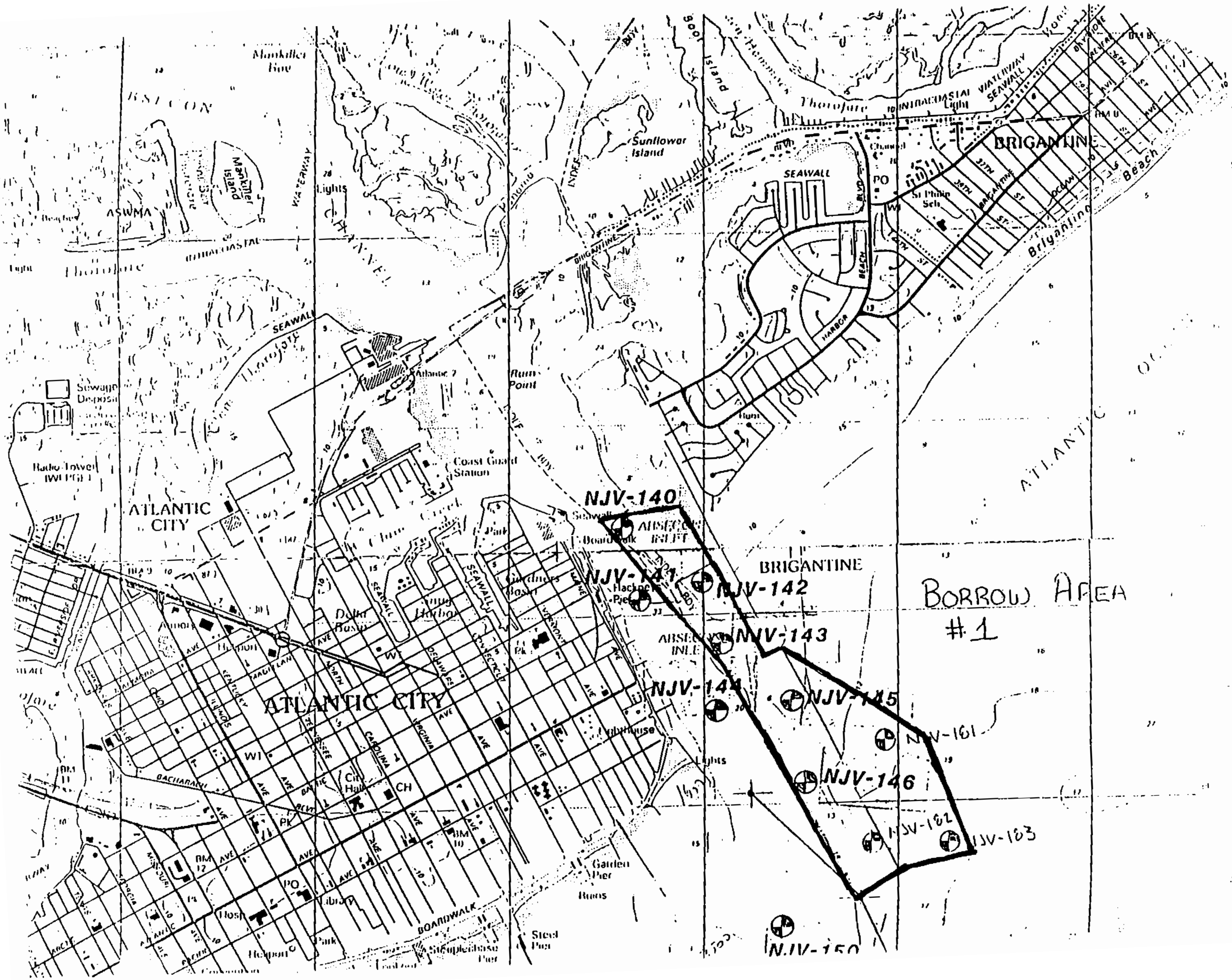
8. Restrictions: No known or potential conflict of interest exists.

9. Security Clearance: No security clearance is required.

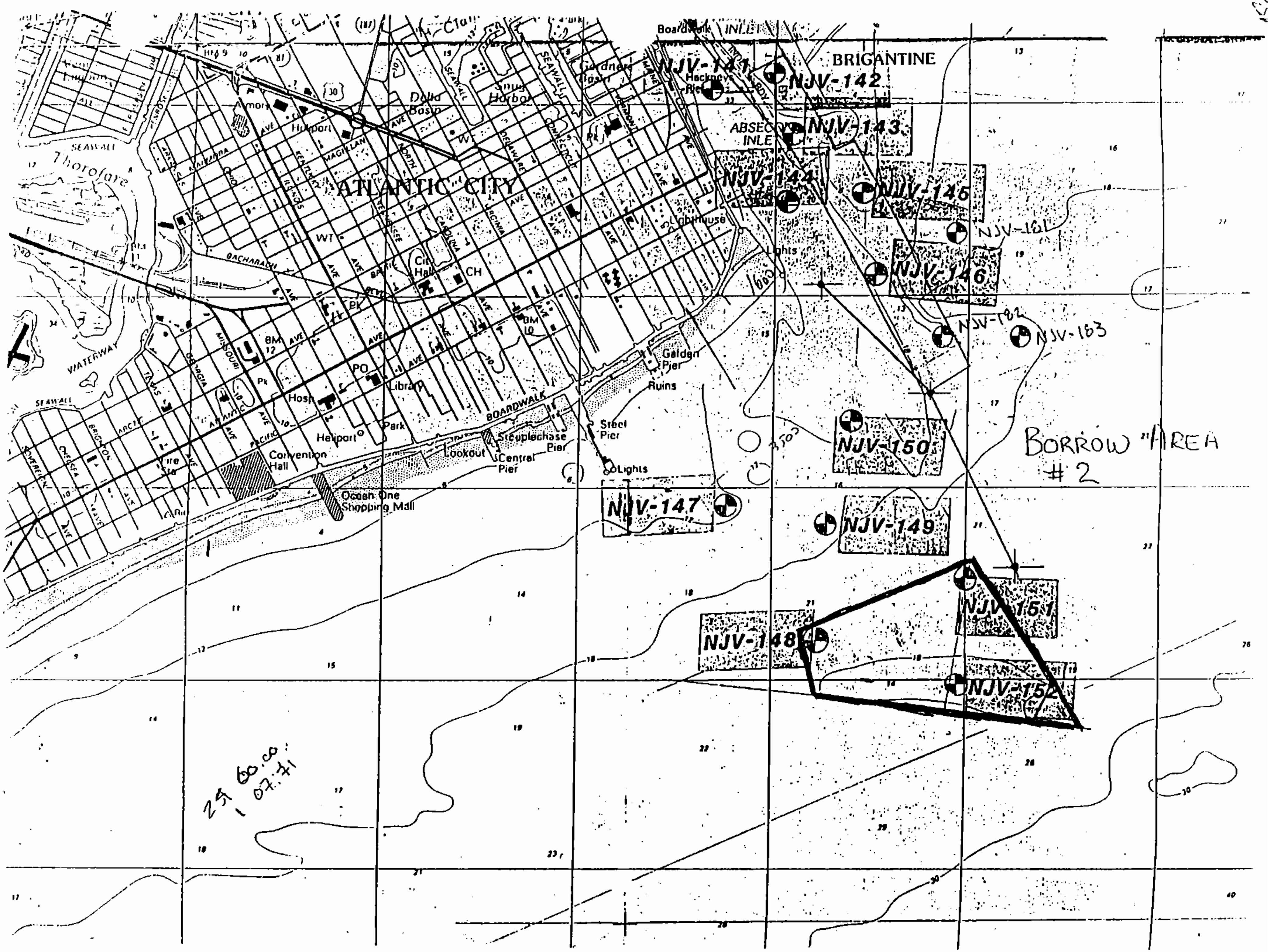
10. Contracting Officer's Technical Representative: Project Biologist: Beth Brandreth, Environmental Resources Branch, (215) 656-6558, (215) 656-6543 (fax). Philadelphia District Corps of Engineers, Wanamaker Building, 100 Penn Square East, Philadelphia, Pennsylvania 19107-3390.

11. Recommended Source: Battelle Ocean Sciences, 397 Washington Street, Duxbury, Massachusetts 02332; (617) 934-0571. Point of Contact: Karen Foster

12. Relevance: Under the National Environmental Policy Act (NEPA) the U.S. Army Corps of Engineers is required to develop an Environmental Assessment (EA) or Environmental Impact Statement (EIS) for its planning projects. The EA/EIS discusses project alternatives and their environmental effects and analyzes measures to avoid or minimize adverse impacts to the environment. Compliance with environmental quality protection statutes must be met for each planning project. In accordance with Section 401 of the Clean Water Act and the Coastal Zone Management Act, potential impacts of the proposed project on natural resources should be scientifically evaluated. This scope of work attempts to assess the natural resources which may be impacted by the proposed project. This information will advance the scientific and technical knowledge necessary in order to meet the national goals of these statutes.



BORROW AREA
#1
NJV-140
NJV-141
NJV-142
NJV-143
NJV-144
NJV-145
NJV-146
NJV-150
NJV-161
NJV-162
NJV-163
ATLANTIC CITY
BRIGANTINE
ATLANTIC
Sunflower Island
Mankiller Island
Coast Guard Station
Rum Point
SEAWALL
BOARDWALK
Garden Pier
Steel Pier
Brigantine Beach



ATLANTIC CITY
BRIGANTINE
BORROW AREA #2
NJV-141
NJV-142
NJV-143
NJV-144
NJV-145
NJV-146
NJV-147
NJV-148
NJV-149
NJV-150
NJV-151
NJV-152
NJV-181
NJV-182
NJV-183
ABSECON INLET
Thorofare
WATERWAY
SEAWALL
BOARDWALK
Convention Hall
Heliport
Park
Library
PO
Hosp
City Hall
CH
Lighthouse
Lookout
Central Pier
Steeplechase Pier
Steel Pier
Garden Pier
Ruins
Lights
Ocean One Shopping Mall
Dolla Basin
Snug Harbor
Gardners Basin
Hackneys Pier
Boardwalk

BORROW SOURCE AREA #1 IS DEFINED BY THE FOLLOWING BOUNDARY POINTS

1. N 39° 22' 35"
   W 74° 24' 50"
2. N 39° 22' 10"
   W 74° 24' 24.6"
3. N 39° 21' 30"
   W 74° 23' 56"
4. N 39° 21' 34"
   W 74° 23' 46"
5. N 39° 21' 36"
   W 74° 23' 29"
6. N 39° 21' 56"
   W 74° 23' 40"
7. N 39° 22' 12"
   W 74° 24' 11"
8. N 39° 22' 11"
   W 74.24' 16.5"
9. N 39° 22' 37"
   W 74° 24' 32"

TOTAL AREA = 269.34 ACRES

BORROW SOURCE AREA #2 IS DEFINED BY THE FOLLOWING BOUNDARY POINTS

(1) N 39° 20' 50"
W 74° 24' 45"

(2) N 39° 20' 39"
W 74° 24' 20"

(3) N 39° 20' 34"
W 74° 23' 32"

(4) N 39° 20' 40"
W 74° 23' 27"

(5) N 39° 21' 01"
W 74° 23' 45"

TOTAL AREA = 218.28 ACRES

Borrow Area #1 Boundary Limits in New Jersey State Plane Coordinates (Feet), 1983 Datum

(1) N 197793.34
E 516491.89

(2) N 197993.00
E 517879.90

(3) N 195363.84
E 519099.71

(4) N 195262.01
E 518463.76

(5) N 195465.47
E 519531.50

(6) N 193849.43
E 521967.69

(7) N 191217.64
E 520714.14

(8) N 191623.21
E 521499.07

(9) N 191827.12
E 522833.96

BORROW AREA # 2 BOUNDARY LIMITS IN NEW JERSEY STATE PLANE COORDINATES (FEET), 1983 DATUM

(1) N 187166.85
E 516869.65

(2) N 186055.96
E 518834.60

(3) N 188284.71
E 521581.45

(4) N 1[illegible]161.82
E 522997.88

(5) N 185554.33
E 522605.83

CULTURAL INVESTIGATIONS

HUNTER RESEARCH

DRAFT

A PHASE 1 SUBMERGED AND SHORELINE CULTURAL RESOURCES INVESTIGATION ABSECON ISLAND ATLANTIC COUNTY, NEW JERSEY

CONTRACT DACW61-94-D-0010
DELIVERY ORDER #6

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

Prepared by:
Dolan Research, Inc.
4425 Osage Avenue
Philadelphia, PA 19104

Hunter Research, Inc.
714 South Clinton Avenue
Trenton, NJ 08611

Submitted to:

U.S. Army Corps of Engineers
Philadelphia District
The Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Prepared under the supervision of:

J. Lee Cox, Jr. (Dolan Research, Inc.)

Richard Hunter (Hunter Research, Inc.)
Principal Investigators

March 1995

MANAGEMENT SUMMARY

This report describes the results of a Phase 1 submerged and shoreline cultural resources investigation of two proposed sand borrow areas and an eight-mile segment of tidal zone and shoreline along Absecon Island, Atlantic County, New Jersey. This study was performed in connection with a program of beach nourishment and shoreline erosion control planned by the Philadelphia District of the U.S. Army Corps of Engineers. Investigative tasks included: background and documentary research; terrestrial pedestrian survey of the shoreline at low tide; underwater archaeological survey using magnetic, acoustic and bathymetric remote sensing equipment; analysis and evaluation of assembled research and field data; and preparation of this report. Since the principal potential archaeological impacts of this project will occur offshore from New Jersey's Atlantic coast, the investigative emphasis was mostly placed on background research, paleoenvironmental analysis and underwater survey activities.

No known prehistoric resources have been identified within the project area, but it should be noted that the level of study precluded a full evaluation of prehistoric archaeological potential. For future large-scale studies of this type, it is suggested that consideration be given to limited core sampling as a means of reconstructing the paleoenvironment of formerly exposed terrain that has been inundated over the past ten to 15 millennia. This would provide a more solid basis for assessing prehistoric archaeological potential within the Atlantic Coastal Zone. No further prehistoric archaeological analysis is recommended for the shoreline, since beach nourishment should serve to protect buried resources in this zone, if indeed they exist.

The potential for early historic archaeological terrestrial resources is considered negligible along New Jersey's Atlantic coast and no evidence for significant resources of this type was observed along the shoreline. No further investigation of early historic archaeological terrestrial resources is considered necessary in connection with the proposed project.

Various structures were identified along the shoreline (notably, piers and groins), some of which are in excess of 50 years in age and therefore meet the age criterion of the National Register of Historic Places. Two entertainment piers -- the Steeplechase Pier and the Garden Pier in Atlantic City -- have been previously identified as possibly eligible for inclusion in the National Register. In this consultant's opinion, both of these piers and other shoreline structures of suitable antiquity should be considered important historic features integral to the Absecon Island communities of Atlantic City, Ventnor, Margate and Longport. It is recommended that beach nourishment be performed sensitively around these structures; it should also be noted that their preservation can assist in stabilizing the shoreline.

Background research indicates extensive historic maritime activity in the Absecon Island/Absecon Inlet vicinity. Over 130 shipwrecks or maritime "accidents" have been documented along this section of New Jersey's Atlantic coast and there is consequently a high potential for underwater resources in the vicinity of the proposed sand borrow areas. Remote sensing survey identified five potentially significant underwater resources in Borrow Area 1, each of which was distinguished by a magnetic anomaly that may relate to a shipwreck. If it is not possible to avoid and preserve each of these suspected resources in place, further underwater archaeological investigation is recommended to establish the nature of each anomaly.

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CHAPTER 1

INTRODUCTION

A. Project Background and Scope-of-Work

The following technical report describes a Phase I Submerged and Shoreline Cultural Resources Investigation performed for two offshore sand borrow areas and an eight-mile segment of the tidal zone adjoining Absecon Island, Atlantic County, New Jersey (Figures 1.1 and 1.2). This work was performed for the Philadelphia District of the U.S. Army Corps of Engineers (USACOE) by Hunter Research, Inc. and Dolan Research, Inc. in connection with plans for beach nourishment along New Jersey's Atlantic shoreline. Beach nourishment, in this instance, is being considered by the USACOE as a suitable solution to erosion along this section of the Atlantic County shoreline.

The cultural resources investigations reported on here represent part of a program of ongoing environmental studies that the USACOE is carrying out in cooperation with the New Jersey Department of Environmental Protection and Energy. The work was carried out as Delivery Order No. 6 under Contract DACW61-94-D-0010 between Hunter Research, Inc. and the U.S. Army Corps of Engineers (Philadelphia District). Dolan Research, Inc. operated as a subconsultant to Hunter Research, Inc., supplying underwater archaeological survey services.

The cultural resources investigations involved two principal work elements:

> 1). an underwater archaeological survey designed to locate targets associated with submerged historic and archaeological resources within the two proposed sand borrow areas; and
>
> 2). a terrestrial survey along approximately eight miles of the Absecon Island shoreline and tidal zone to locate any visible remains of prehistoric and historical archaeological resources.

Tasks performed included: background and documentary research (for both the underwater and terrestrial surveys); acoustic, magnetic and bathymetric remote sensing with follow-up target analysis (underwater survey only); a pedestrian survey, carried out at low tide (terrestrial survey only); analysis of assembled research and field data; and preparation of this report. The purpose of these investigations has been twofold: to determine the presence or absence of submerged or shoreline cultural resources that are potentially eligible for inclusion in the National Register of Historic Places in areas which might be affected by proposed sand borrow activities; and to assess likely project impacts and make recommendations as to the need for further cultural resources studies, if potentially significant resources are identified which may be adversely affected by the proposed project actions.

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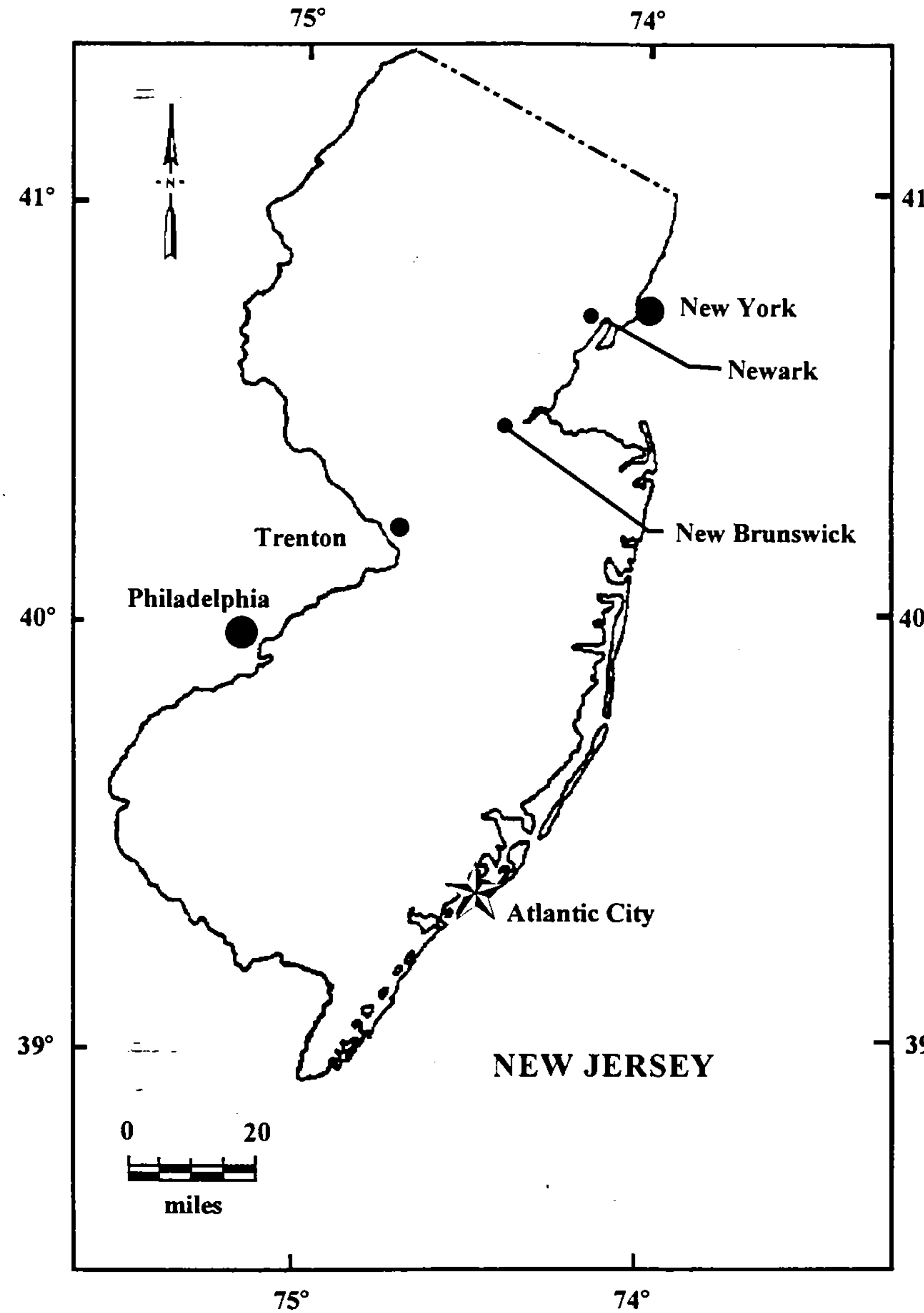

Figure 1.1. Location of Project Area (starred).

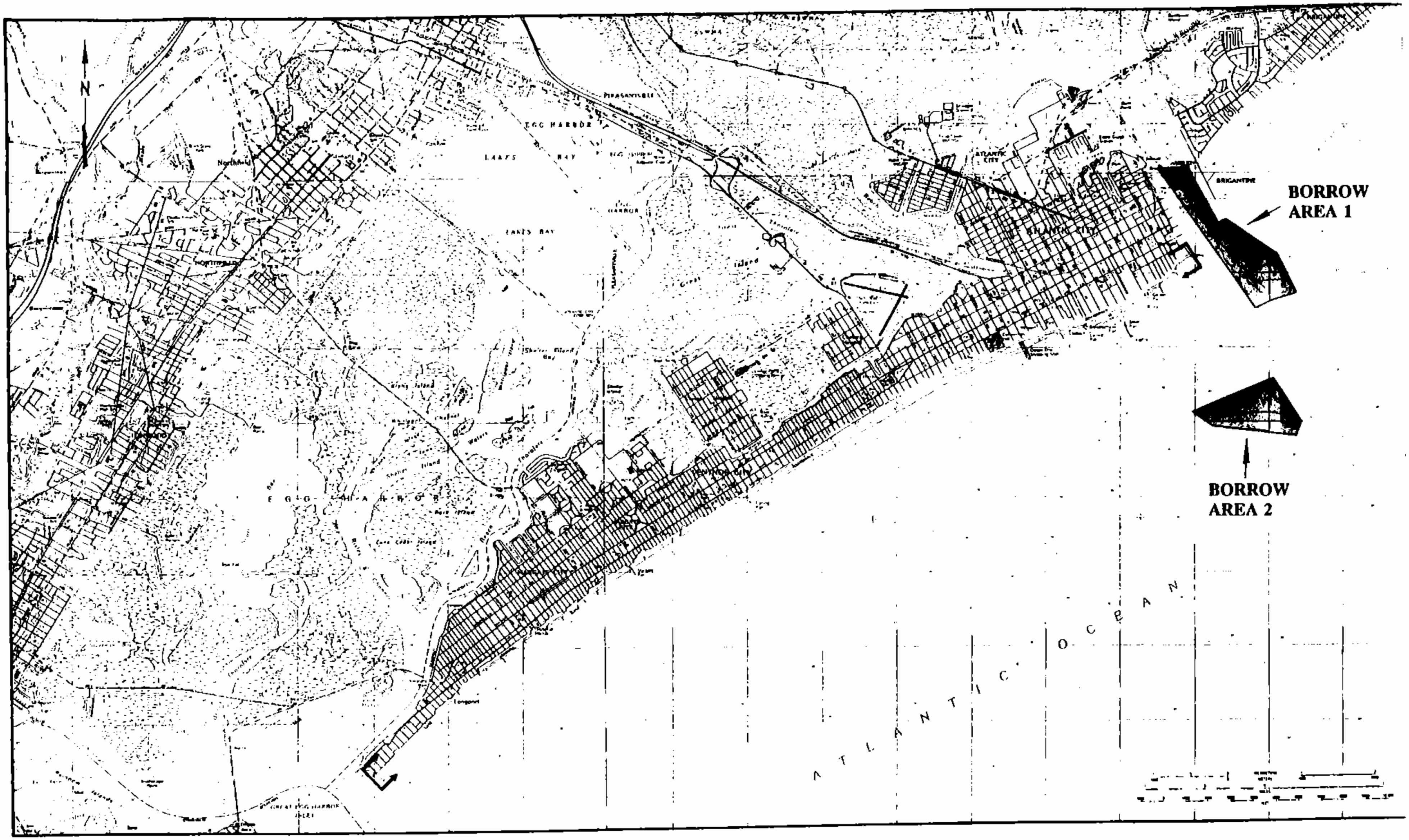

Figure 1.2. Detailed Location of Project Area. The limits of the terrestrial survey area are indicated by arrows and the proposed sand borrow areas are shaded. Source: USGS 7.5' Topographic Series, Atlantic City quadrangle (1989); Oceanville quadrangle (1989); Ocean City quadrangle (1989); and Pleasantville quadrangle (1952, photo revised 1972).

These investigations were conducted in accordance with the instructions and intents of various applicable Federal and State legislation and guidelines governing the evaluation of project impacts on archaeological resources, notably: Section 101(b)(4) of the National Environmental Policy Act of 1969; Section 1(3) and 2(b) of Executive Order 11593; Section 106 of the National Historic Preservation Act; 23 CFR 771, as amended October 30, 1980; the guidelines developed by the Advisory Council on Historic Preservation published November 26, 1980; the amended Procedures for the Protection of Historic and Cultural Properties as set forth in 36 CFR Part 800 (October 1, 1986); and Executive Order 215.

B. Criteria of Evaluation

The information generated by these investigations was considered in terms of the criteria for evaluation outlined by the U.S. Department of the Interior, National Register Program:

The quality of significance in American history, architecture, archaeology and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling and association, and:

> A. that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> B. that are associated with the lives of persons significant in our past; or
>
> C. that embody the distinctive characteristics of a type, period or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. that have yielded, or may be likely to yield information important in prehistory or history.

National Register of Historic Places Bulletin 20 clarifies the National Register review process with regard to shipwrecks and other submerged cultural resources. Shipwrecks must meet at least one of the above criteria and retain integrity of location, design, settings, materials, workmanship, feelings and association. Determining the significance of a historic vessel depends on establishing whether the vessel is:

1. the sole, best, or a good representative of a specific vessel type; or

2. is associated with a significant designer or builder; or

3. was involved in important maritime trade, naval recreational, government, or commercial activities.

Properties which qualify for the National Register, must have significance in one or more "Areas of Significance" that are listed in National Register Bulletin 16A. Although 29 specific categories are listed, only some are relevant to the submerged cultural resources. Architecture, commerce, engineering, industry, invention, maritime history and transportation are potentially applicable data categories for the type of submerged cultural resources which may be expected in the Absecon Island study area.

Ordinarily, cemeteries, birthplaces or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do meet the criteria or if they fall within the following categories:

A. a religious property deriving primary significance from architectural or artistic distinction or historical importance; or

B. a building or structure removed from its original location but which is significant primarily for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or

C. a birthplace or grave of a historical figure of outstanding importance if there is no other appropriate site or building directly associated with his productive life; or

D. a cemetery which derives its primary significance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or

E. a reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or

F. a property primarily commemorative in intent of design, age, tradition, or symbolic value has invested it with its own historic significance; or

G. a property achieving significance within the past 50 years if it is of exceptional importance.

C. Definition of Terms

The following definitions are from the Department of the Interior. National Register of Historic Places 36 CFR 63 (Federal Register, Vol. 42, No. 183. Wed. Sept. 21, 1977. pp. 47666-67):

1. A "site" is the location of a significant event, or prehistoric or historic occupation or activity or a building or structure whether standing, ruined, or vanished where the location itself maintains historical or archaeological value regardless of the value of any existing structures.

2. A "building" is a structure created to shelter and form of human activity such as a house, barn, church, hotel or similar structure. "Buildings" may refer to a historically related complex, such as a courthouse and jail or a house and barn.

3. A "structure" is a work make up of interdependent and interrelated parts in a definite pattern or organization. Constructed by man. it is often an engineering project large in scale.

4. An "object" is a material thing of functional, aesthetic, cultural, historical, or scientific value that may be, by nature or design, movable yet related to a specific setting or environment.

D. Previous Research and Principal Information Sources

Previous cultural resources investigations have not addressed the cultural prehistory or early history of the presently submerged portions of the Atlantic County shoreline in any detailed manner owing to the inaccessibility of permanently inundated terrain. In addition, no previous archaeological studies appear to have been carried out within the tidal zone offshore from Absecon Island. Despite a statewide survey of archaeological resources conducted in the early part of this century (Skinner and Schrabisch 1913) and a number of recent cultural resources investigations in the project vicinity (Wilson 1976; Historic Sites Research 1980; Regensburg 1975; Cultural Heritage Research Services, Inc. 1984, 1985; Richard Grubb and Associates, Inc. 1992; Mounier 1993), no previously reported discoveries of prehistoric or early historic sites on Absecon Island have been found in the current survey. The closest documented prehistoric sites to Absecon Island are located in Pleasantville, approximately three miles to the northwest of the study area (New Jersey State Museum site maps and files [sites 28-At-3 thru 28-At-7]). The absence of documented prehistoric resources may not be a true reflection of prehistoric activity on Absecon Island, however, since the area has been heavily built-up for over a century and systematic identification of archaeological sites has only taken place in recent decades. No potentially significant historical archaeological resources have been identified along the Absecon Island shoreline.

While the prehistoric and historical archaeology of Absecon Island has been little studied and scant information is available concerning Native American or early European activity in the area, extensive paleoenvironmental research has been conducted along the Atlantic coastline and in the nearby Delaware Bay (e.g., Belknap and Kraft 1977; Kraft 1977a; Kraft et al. 1979; Belknap and Kraft 1981; Kraft et al. 1983). This research has some bearing on the potential for prehistoric resources in the offshore and tidal zone and is summarized below in Chapter 3.

No formal underwater archaeological investigations have been conducted previously in the vicinity of the Absecon Inlet where the two proposed sand borrow areas are located, but a number of studies of similar type have been performed along other nearby sections of New Jersey's Atlantic coast. In June, 1982 a magnetometer survey was conducted for the USACOE in connection with a proposed borrow area, 6,000 feet long by 1,650 feet wide, located 1.25 miles offshore from Cape May. Nine anomalies were identified and avoidance of these features was recommended (Historic Sites Research 1982). In 1985, a remote sensing survey was undertaken for the USACOE in connection with a proposed borrow area offshore from the Great Egg Harbor Inlet (Tidewater Atlantic Research 1985). Supplementary underwater archaeological research was subsequently performed in the same general area around the Great Egg Harbor Inlet and offshore from Peck Beach, Ocean City (Dolan Research, Inc. 1993). Neither of these surveys identified potentially significant submerged cultural resources.

In the fall of 1993, the remains of what appears to be an early 18th-century British vessel were unearthed on land during initial construction for a parking lot east of the Showboat Casino (situated in the block defined by Maryland, New Jersey and Pacific Avenues and the boardwalk). The initial discovery involved a number of large timbers, 18 inches square in cross section, found during test borings. These were thought at first to be the remains of an early bulkhead, but upon closer examination were identified as the ribs and keel of a British vessel, measuring some 140 feet in length, believed to have been constructed in the first decade of the 18th century. The excavation was enlarged to a 15-foot-wide trench to determine the extent of the resource. Correspondence on file at the New Jersey Historic Preservation Office indicates that plans were being formulated to remove the remains and store them at Gardner's Basin, a maritime museum in nearby Brigantine. No further details have been reported concerning this find and no formal archaeological recording of the vessel appears to have been undertaken.

Historic architectural survey was not a significant work component in the current investigation. Examination of the maps and files of the New Jersey Historic Preservation Office showed that there are 18 historic resources on Absecon Island that are currently listed in the State and National Registers of Historic Places. None of these resources is located within the limits of the current study area, the three closest being the Atlantic City Convention Hall, the Shelburne Hotel and the John Stafford Historic District.

A number of piers project out into the ocean from the shoreline of Absecon Island. From south to north, these are: the Margate Pier; the Ventnor City Fishing Pier; the Ocean One Mall (formerly the Million Dollar Pier); the Central Pier; the Steeplechase Pier; the Steel Pier; and the Garden Pier. Two of these piers -- the Steeplechase Pier and the Garden Pier -- were documented by the Atlantic City Historic Building Survey carried out in 1980 by the University of Pennsylvania and the Clio Group for the New Jersey Historic Preservation Office. Both were considered possibly eligible for inclusion in the State and National Registers of Historic Places (University of Pennsylvania et al. 1980). Within Atlantic City proper, to the northwest of the boardwalk, the Riviera Apartments (at Raleigh Avenue), the Ritz Carlton Hotel (at Iowa Avenue), the Brighton Park building (at Park Place) and the Seaside Hotel (at Pennsylvania Avenue) were also judged by this survey to have some historical merit. Except for the piers noted above, all of these latter resources are located outside the current limits of the study area. In addition, the communities of Longport, Margate and Ventnor were examined as part of an architectural survey of North Atlantic County conducted by The History Store in 1986. A total of 24 historic buildings were noted between the Seawall/Boardwalk and Atlantic Avenue, but no assessment of National Register eligibility was offered for any of these resources. Again, these structures are located outside the current limits of the study area (The History Store 1986).

A wide variety of information sources has been consulted during the course of this study. Basic information sources routinely examined for all aspects of USACOE cultural resources work in New Jersey include the site maps, files, technical reports and planning documents held by the New Jersey Historic Preservation Office and the New Jersey State Museum, archival data and published historical materials held by the New Jersey State Archives and the New Jersey State Library, and materials held by the Philadelphia District office of USACOE. Local and county libraries and historical societies (in Atlantic City, Ventnor and Somers Point) were visited by project personnel during the course of background research.

Specifically for the underwater aspects of this study and other underwater investigations being conducted concurrently for USACOE, project personnel contacted local archaeologists, watermen, sport and commercial divers, knowledgeable professional and avocational historians, and interested lay persons with knowledge of New Jersey maritime history. Primary and secondary sources, maps and atlases pertaining to the maritime history of New Jersey were examined at maritime institutions, federal, state and local libraries and historical societies. At the National Archives, a variety of record groups containing information on shipwrecks, ship construction, naval activity, and maritime trade activities were consulted. Site specific research, pertaining to individual vessels was conducted at the Philadelphia Maritime Museum, the Historical Society of Pennsylvania, and the Steamship Historical Society in Baltimore. Other national and regional repositories visited in conjunction with the maritime historical research include the Cartographic Branch of National Archives, Library of Congress, the Free Library of Philadelphia, University of Pennsylvania's Van Pelt Library, the University of Maryland library system in College Park, as well as the various New Jersey State agencies and USACOE offices noted above.

E. Research Methodology and Research Design

From a methodological standpoint, since this cultural resources investigation focussed chiefly on the potential for submerged resources in the Absecon Inlet area and shoreline resources within the tidal zone, a strongly cartographic and geographic approach was adopted for the background research. Emphasis was placed initially on mapping known and suspected resources, and analyzing these locations in relation to changes in sea level, shoreline configuration and land use. Cartographic research was supplemented with oral historical research, a review of secondary sources and consideration of paleogeographic issues. Fieldwork relied chiefly on remote sensing (for the underwater survey) and surface inspection and interviewing (for the terrestrial survey). At this level of investigation, this non-intrusive landscape and literature-based approach to the study of cultural resources provides the most effective means of assessing archaeological potential without engaging in a complex and expensive program of subsurface investigation and diving.

The potential for prehistoric resources was assessed with reference to standard texts on New Jersey prehistory (e.g., Kraft 1986) and available preservation planning documents, including the overall framework and specific historic contexts for the New Jersey Comprehensive Historic Preservation Plan (Ames et al. 1987), and earlier definition of key archaeological research issues (e.g., Chesler 1982). In framing research questions concerning historic resources, the project study area was considered to possess a low potential for all types of historic resources, except shipwrecks, since most of it presently lies underwater and was submerged throughout the historic period. The on-land portions of the study area were beachfront for the bulk of the historic period, and apart from the construction of piers and sporadic attempts at shoreline protection in support of residential, commercial and recreational land use over the past century or so, this zone has remained undeveloped.

The offshore borrow areas were considered to have a moderate potential for shipwrecks, a potential that could only be effectively examined through systematic documentary research and remote sensing (for detail on the remote sensing methodology, see below, Chapter 5). Documentary data were used to provide a framework for identifying submerged historic archaeological resources which may have been deposited within the two offshore borrow areas or within the tidal zone, and to determine the extent of subsequent activities that may have removed or disturbed such resources. Both primary and secondary source materials, including historic maps and charts, were consulted to provide data on local and regional historical developments, while local residents and other experts on New Jersey history and archaeology were also contacted.

Background research on the historic period established a generalized context for ultimate evaluation of any historic submerged sites that might be identified. While the emphasis of background research focused on maritime activity in the project vicinity. a broad based historic overview is essential for providing the proper framework for assessing the potential significance of submerged cultural resources. Historic maps, secondary and primary shipwreck lists. primary historical accounts, newspapers, and county and thematic histories were all used to develop a set of expected resources within the project area. Specifically, data from the background research was used to generate a list of shipwrecks and ship losses along this section of the Atlantic shore.

CHAPTER 2

GEOGRAPHICAL SETTING

The study area consists of an eight-mile stretch of the Atlantic Ocean shoreline consisting of the shoreline and tidal zone adjacent to Absecon Island plus two proposed offshore sand borrow areas, one of which is located in and immediately outside the Absecon Inlet (at the northeastern end of Absecon Island), and the second is located approximately two miles south of the Absecon Inlet in the Atlantic Ocean. Absecon Island lies within the outer lowland subprovince of the Atlantic Coastal Plain physiographic zone, roughly 75 miles southwest of Sandy Hook (at the entrance to New York harbor) and 40 miles northeast of Cape May (at the entrance to Delaware Bay) (Figure 1.1). Overall, the topography of the Coastal Plain is characterized by level to gently rolling terrain, with more than one-half of the surface area lying below 100 feet above sea level. The area examined during this study lies at or below sea level and is subject to tidal fluctuation. The underlying geology consists of the Pleistocene sands and gravels of the Cape May Formation originally laid down in the Sangamon interglacial stage. These deposits mask earlier sediments of Cretaceous age (Wolfe 1977:138-139, 288-290).

Absecon Island is an elongated barrier island, approximately eight miles long, which is bounded on the southeast by the Atlantic Ocean, on the northeast by the Absecon Inlet, on the southwest by the Great Egg Harbor Inlet, and on the northwest by an amorphous series of tidal wetlands and marshy islands. The Absecon Inlet connects Absecon Bay and Reeds Bay with the Atlantic Ocean and forms the entrance to the harbor waters of Atlantic City. The Great Egg Harbor Inlet connects three bays -- Great Egg Harbor, Scull and Lakes -- with the Atlantic Ocean. The Absecon Inlet has been periodically improved and maintained for navigation under a Federal project which provides for a channel into Atlantic City that is 20 feet deep and 400 feet wide.

The urban metropolis and casino nexus of Atlantic City occupies the northeastern third of Absecon Island, while the remainder is occupied by the densely built-up suburban communities of Ventnor City, Margate City and Longport (Figure 1.2; Plates 2.1-2.4). The ocean frontage of Atlantic City, which consists of soils classified as belonging to the coastal beach-urban land complex (Cu), has been developed extensively for recreation and commerce. The principal feature along the frontage is the boardwalk, that extends along the entire ocean and inlet frontage of Atlantic City. Five large piers with decks extend seaward at the level of the boardwalk across the beach and out over the water (Johnson 1978). Towards the southwestern end of the island, in Ventnor, Margate and Longport, the ocean frontage is defined by a sea wall, against which presses a sandy beach, retained in places by groynes projecting out into the ocean. Two large piers project into the ocean in the southwestern half of the island, one in Ventnor City and the other in Margate.

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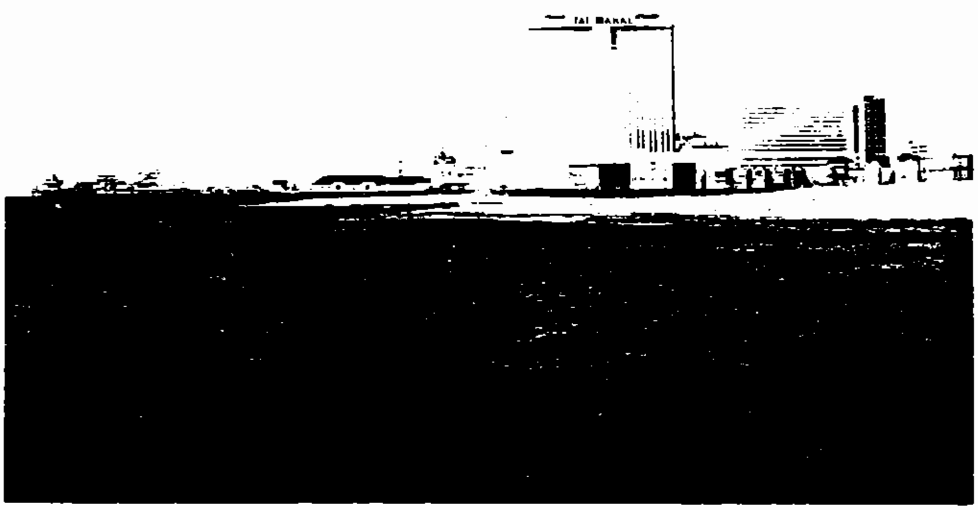

Plate 2.1. General view looking southwest from the Absecon Inlet showing the northeastern end of Absecon Island. The Atlantic Ocean is located at left of the view; the Taj Mahal Casino is at center right, with the Showboat Casino to the rear and right (Photographer: Michael Tomkins, September 1994) [HRI neg. 94027/1:3/3A].

Plate 2.2. General view looking northeast along the Atlantic shoreline of Absecon Island from Providence Avenue. The Atlantic Ocean is at right with the Ocean One Shopping Mall on the horizon at the center of the view (Photographer: Michael Tomkins, September 1994) [HRI neg. 94027/1:4/4A].

Plate 2.3. General view looking southwest along the Atlantic shoreline of Absecon Island from Providence Avenue. The Atlantic Ocean is at left (Photographer: Michael Tomkins, September 1994) [HRI neg. 94027/1:8/8A].

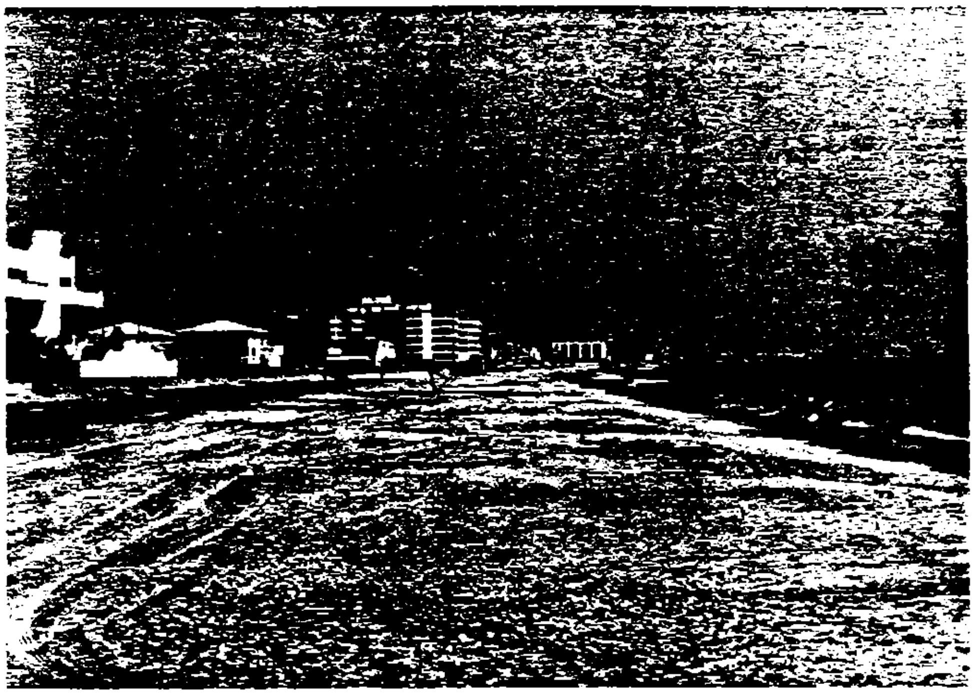

Plate 2.4. General view looking northeast from Great Egg Harbor Inlet showing the Atlantic shoreline at the southwestern end of Absecon Island. The Atlantic Ocean is at right with the Atlantic City skyline visible on the horizon beyond (Photographer: Michael Tomkins, September 1994) [HRI neg. 94027/1:13/13A].

Borrow Area 1, consisting of 270 acres, is situated along the northeast side of the navigational channel that passes through the Absecon Inlet (Figure 1.2). The irregular-shaped area extends away to the northeast from the navigational channel and covers an area to the southeast of the jetty on the southwest tip of Brigantine Island. Water depths across Borrow Area 1 range from less than three feet, mean low water (MLW), to 25 feet (MLW) in the vicinity of the navigational channel.

Coordinates for the corners of Borrow Area 1 are expressed in the New Jersey State Plane Coordinate System (NAD 83) as follows:

Site Name	Northings	Eastings
Borrow Area #1	(1) 197793	516491
	(2) 197993	517879
	(3) 195363	519099
	(4) 195262	518463
	(5) 195465	519531
	(6) 193849	521967
	(7) 191217	520714
	(8) 191623	521499
	(9) 191827	522833

Borrow Area 2, consisting of 220 acres, is located approximately two miles south of the Absecon Inlet. The area has five sides, with its longest axis oriented in a northeast-southwest direction and measuring approximately 6,000 feet (Figure 1.2). Water depths across Borrow Area 2 range from 18 feet (MLW) to 31 feet (MLW).

Coordinates for the corners of Borrow Area 2 are expressed in the New Jersey State Plane Coordinate System (NAD 83) as follows:

Borrow Area #2	(1) 187166	516869
	(2) 186055	518834
	(3) 188284	521581
	(4) 186161	522997
	(5) 185554	522605

CHAPTER 3

PALEOENVIRONMENT AND PREHISTORIC BACKGROUND

A. Mid-Atlantic Coastal Plain Prehistory

Barrier islands and adjacent Atlantic coastal regions are among the most dynamic environments currently found on earth, and dynamic change was no less of a hallmark in the prehistoric past. As a consequence, paleoenvironmental reconstruction for any given coastal geographical location, such as the Middle Atlantic coastal zone, is an extraordinarily complex task fraught with uncertainty and a sparsity of scientific data.

The Pleistocene Epoch witnessed a series of cold periods and associated "ice ages," the most recent of which terminated approximately 14,000 to 12,000 years ago. One of the most dramatic effects of these "ice ages" was the lowering of ocean levels worldwide as sea water was frozen and trapped in glaciers and continental ice sheets. Milliman and Emery (1968) argue on the basis of 80 radiocarbon samples taken along the Atlantic continental shelf that sea levels 30,000 to 35,000 years ago were close to those at present. Sea levels dropped subsequently as much as 130 meters during the final Wisconsinan glacial advance around 16,000 years ago. Along the Atlantic coast, ocean beaches during this period lay at the edge of the modern continental shelf, perhaps 100 kilometers east of the modern New Jersey coastline (Figure 3.1). Belknap and Kraft (1977) question the maximum depth of sea level drop, but agree with the overall pattern.

Overall climatic patterns have changed on a regional and continental basis during the Holocene Epoch, which began at the end of the Pleistocene. Sea levels have continued to rise as a result of the release of water from melting ice sheets. As the sea level rose, it began to transgress, or cover, the land mass of the Coastal Plain (the modern Atlantic continental shelf) to the west. The Holocene marine transgression, or sea level rise, began around 14,000 years ago and proceeded rapidly until around 7,000 years ago (Milliman and Emery 1968; Kraft et al. 1983). The temporal progress of this westward movement of the coastline, which continues at present, is illustrated in Figure 3.1.

The implications of such dynamic changes for any paleoenvironmental reconstruction of the physical locations currently occupied by Absecon Island and adjacent nearshore areas are profound. Climatic changes resulted in a succession of vegetation types moving northward, while the coastline and associated marine and eustatic environments were approaching from the east. As temperatures warmed and the climate alternated between dry and moister periods during the Holocene, open grassy environments were replaced by boreal evergreen forests and

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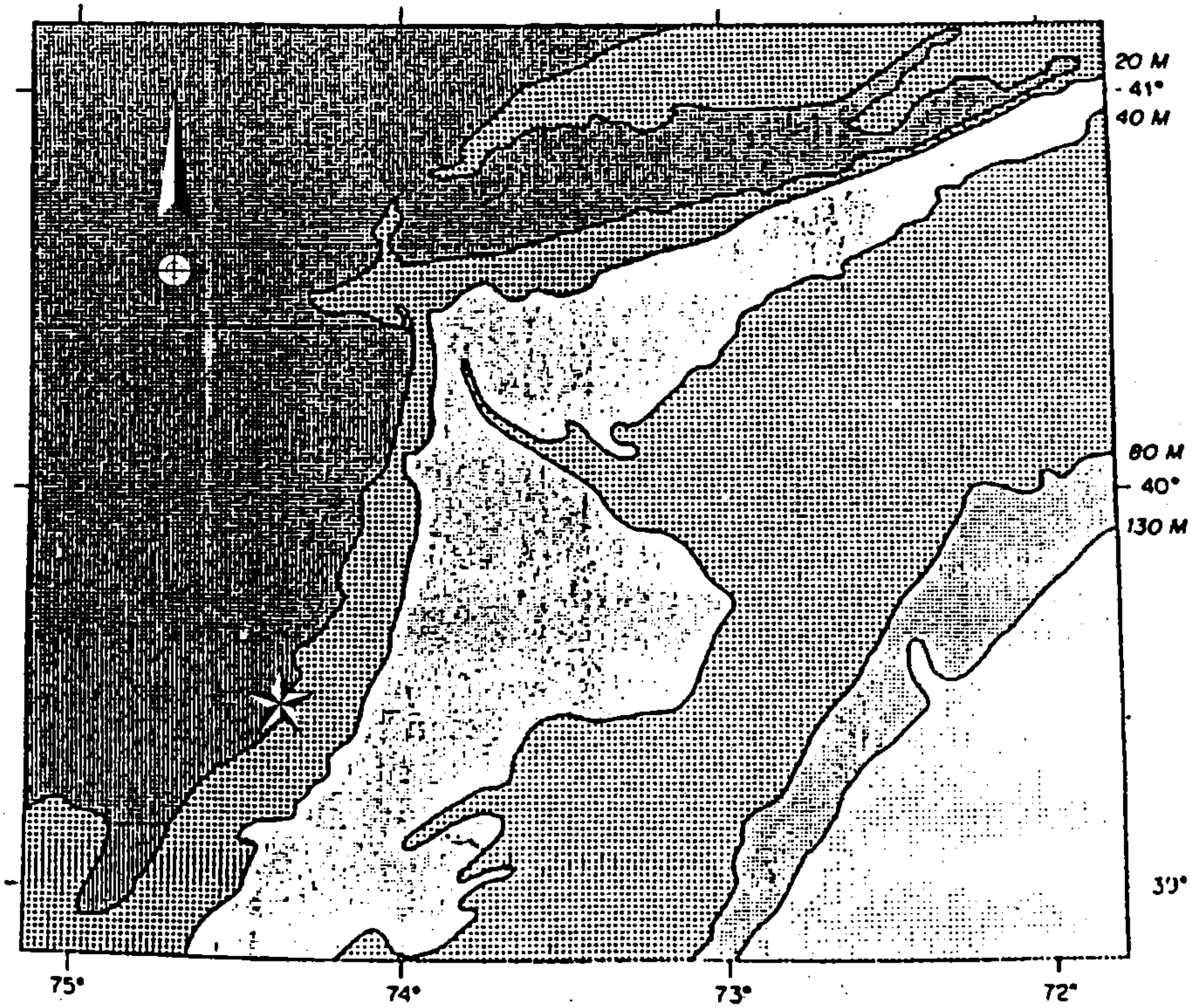

Figure 3.1. Progressive Shifts in Shoreline Positions along the New Jersey and New York Coasts (Source - Edwards and Emery 1977: Figure 3). The location of Absecon Beach is starred.

TABLE 3.1

TEMPORAL CORRELATION OF PALEOENVIRONMENTAL AND CULTURAL DATA

Kyr B.P.	Climate	Vegetation	Culture
15			
	cool & wet Post-glacial	open tundra, spruce park-land	
	cool & wet (warmer) Pre-Boreal	spruce & fir forests	Paleo-Indian early Archaic
	10680		
10	warmer,drier Boreal	pine & birch pine & oak	
	9211		
	warm (near modern) Atlantic	oak, hemlock	Archaic
5			
	4610		
	warmest, driest Sub-Boreal	oak, hickory	Woodland I
	cooler, moister Sub-Atlantic	oak, chestnut	Woodland II
Present			

Source: Dent 1979; Custer 1989; Stewart 1990 then by deciduous forests (Table 3.1). As the coastline steadily approached, the local environment shifted from inland forest to salt tidal marsh to lagoon to coastal sand barrier or nearshore underwater marine deposits. A paleoenvironmental reconstruction must therefore consider both the generally northward-moving vegetational patterns arising from the regional climatic shifts and the westward-moving coastal geomorphological changes associated with coastal environments.

The occupancy of prehistoric man within these dynamic and mobile environments is a primary focus of this study. Human occupation of the Upper Delaware River valley had begun by 11,000-10,500 year B.P. within a boreal forest composed primarily of pine and birch which shifted, as temperatures warmed, to pine and oak (Dent 1979, 1991; Stewart 1990, 1991). Similar vegetation cover extended throughout much of the region, although the presence of favorable microenvironments arising due to topography, solar exposure and surface water (ponds, lakes and rivers) exerted a considerable influence on prehistoric subsistence and adaptations.

Evidence of Paleo-Indian occupation on the Coastal Plain of New Jersey, generally in the form of isolated fluted point sites (Kraft 1977b; Cavallo 1981; Custer et al. 1983) reflect the presence of early human groups in the region. The point distribution is biased by non-systematic surface collection, but nevertheless provides some indication of the nature of Paleo-Indian adaptations. It is argued that these points and associated finds are indicative of hunting and game processing activities (Bonfiglio and Cresson 1978). Similar tool assemblages from the late Paleo-Indian site of Turkey Swamp (Cavallo 1981) near the boundary between the Inner and Outer Coastal Plains are interpreted as reflecting similar activities.

The distribution of surface finds within the Inner Coastal Plain suggests an association with poorly drained bay/basin features (Bonfiglio and Cresson 1978). Custer et al. (1983) note a difference between the continuous size distribution of fluted points from the Outer Coastal Plain as opposed to the lack of the extremes of unresharpened (longer) and heavily resharpened (short) points on the Inner Coastal Plain, and infer an adaptational difference. A settlement model proposed by Gardner (1977) for the Flint Run Paleo-Indian Complex in Virginia has been introduced to suggest that Paleo-Indian groups on the Outer Coastal Plain pursued a "cyclical" mobility pattern with groups returning to the secondary cobble sources of the Inner Coastal Plain. Those groups which occupied the Inner Plain, on the other hand, enjoyed more ready access to these cobble sources. Lithic procurement was thus "embedded" in other subsistence pursuits (Binford 1979; Goodyear 1979), and groups had less need to curate points and other retouched pieces (Custer et al. 1983).

As indicated in the earlier discussion of transgressing sea levels, Absecon Island was not a coastal location at the time of Paleo-Indian occupancy. Edwards and Emery (1977) provide a hypothetical reconstruction of the land area of the Middle Atlantic coast around 10,000 to 12,000 years ago, which serves to illustrate potentially attractive locations for human habitation currently offshore and the eastern positions of environments currently along the Jersey coast

(Figure 3.2). The current site of the South Jersey coastline was covered by inland forest, probably with surface water locations. Thus, any evidence of Paleo-Indian occupation in the vicinity of Absecon Island would not relate directly to coastal environments but to exploitation of inland forest/riverine habitats.

Paleo-Indian hunting and gathering groups would, of course, have also occupied coastal areas, but these geographic locations currently lie on the continental shelf and are submerged. Fossil animal remains have been dredged from locations on the shelf (Merrill et al. 1965; Whitmore et al. 1967; Edwards and Emery 1977) which correlate with former estuarine locations and former shorelines, particularly the mid-shelf position of the shoreline around 10,000-9,000 years B.P. (Figure 3.3). The mammoth, oriented to more open habitats, may have occupied the region prior to the arrival of humans, but the forest mastodon was a contemporary of early Paleo-Indians. Deer and possibly caribou would also have been common inhabitants in the early Holocene forests. Fossil remains of walrus indicate the extent to which water temperatures were lower at the end of the Pleistocene and earlier in the Holocene (Edwards and Merrill 1977). The fossil shells of oysters, a shallow estuarine species, have been recovered from the shelf, and are other indicators of the successive relocation of tidal estuaries (Merrill et al. 1965). Artifacts possibly associated with Paleo-Indian/Early Archaic groups are occasionally found in underwater contexts, such as the bifacially-flaked point recovered recently from Blue Hill Bay on the coast of Maine (Crock et al. 1993).

Hypothetical reconstructions of the Middle Atlantic coast between 6,000 and 8,000 years ago (Figure 3.4) suggest estuarine areas were approaching the current coastline location, but that location remained an inland one (Edwards and Emery 1977:Figure 7; see also Kraft 1977a:Figure 24). Tidal salt marshes may have emerged in advance of the transgressing shoreline in South Jersey by 5,000 years ago, and the shoreline achieved its current location approximately 3,000 years B.P. (Kraft 1977a:Figure 27). Climatic conditions were warm and somewhat moister than in the preceding Boreal phase (Table 3.1), with oak and hemlock as dominant vegetation species (Deevey 1952; Dent 1979), but perhaps with pine persisting in coastal areas.

This time period coincides with the emergence of another archaeologically-defined human adaptational phase, the Archaic. Material culture changes during the Archaic include the appearance of ground stone tools in addition to flaked stone artifacts. The raw materials utilized for tools also shifts from cryptocrystalline rocks to igneous rhyolite, suggestive of shifts in mobility and possibly in social organization (Custer 1986, 1989). Archaic sites have been attributed to macro-band and micro-band base camps in areas of "maximum habitat overlap" as defined by Custer (1989), such as interior freshwater swamps and bay/basin loci. Coastal tidal salt marshes and estuarine environments would have been food resource-rich habitats available for exploitation.

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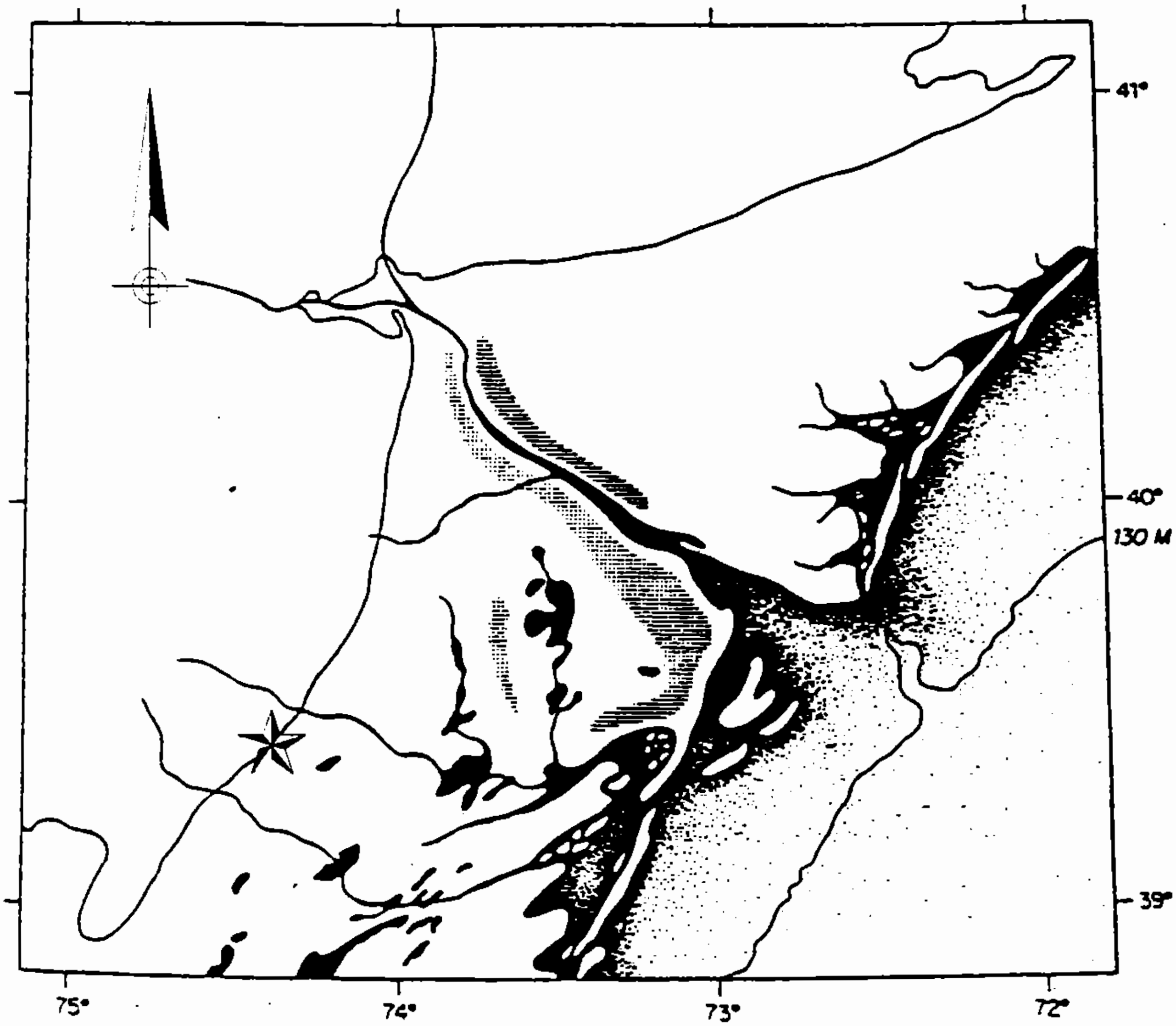

Figure 3.2. - A Reconstruction of the Middle Atlantic Coastal Area 10,000 to 12,000 Years Ago (Source - Edwards and Emery 1977: Figure 6). The location of Absecon Beach is starred.

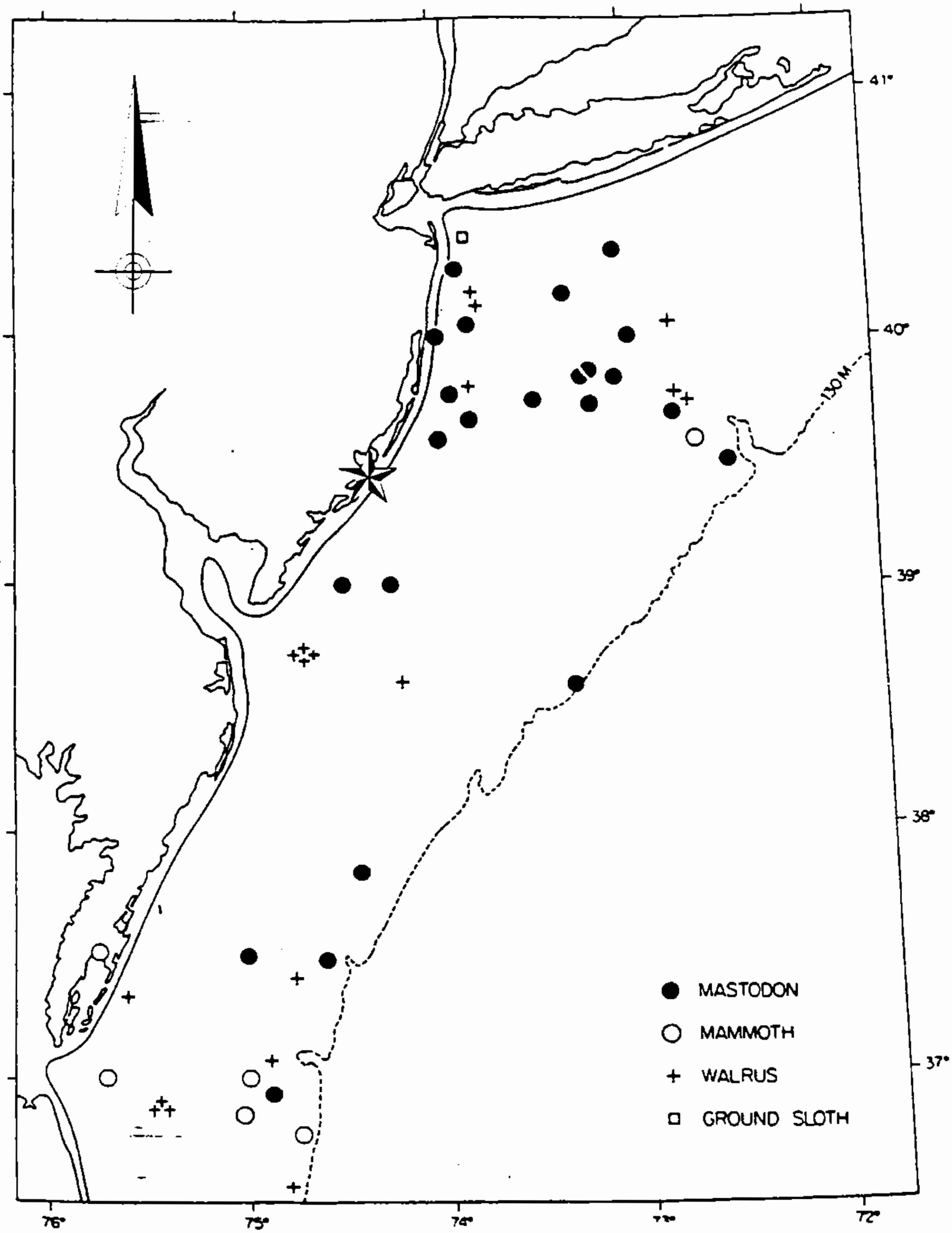

Figure 3.3. Fossil Finds on the Middle Atlantic Continental Shelf (Source - Edwards and Merrill 1977: Figure 11). The location of Absecon Island is starred.

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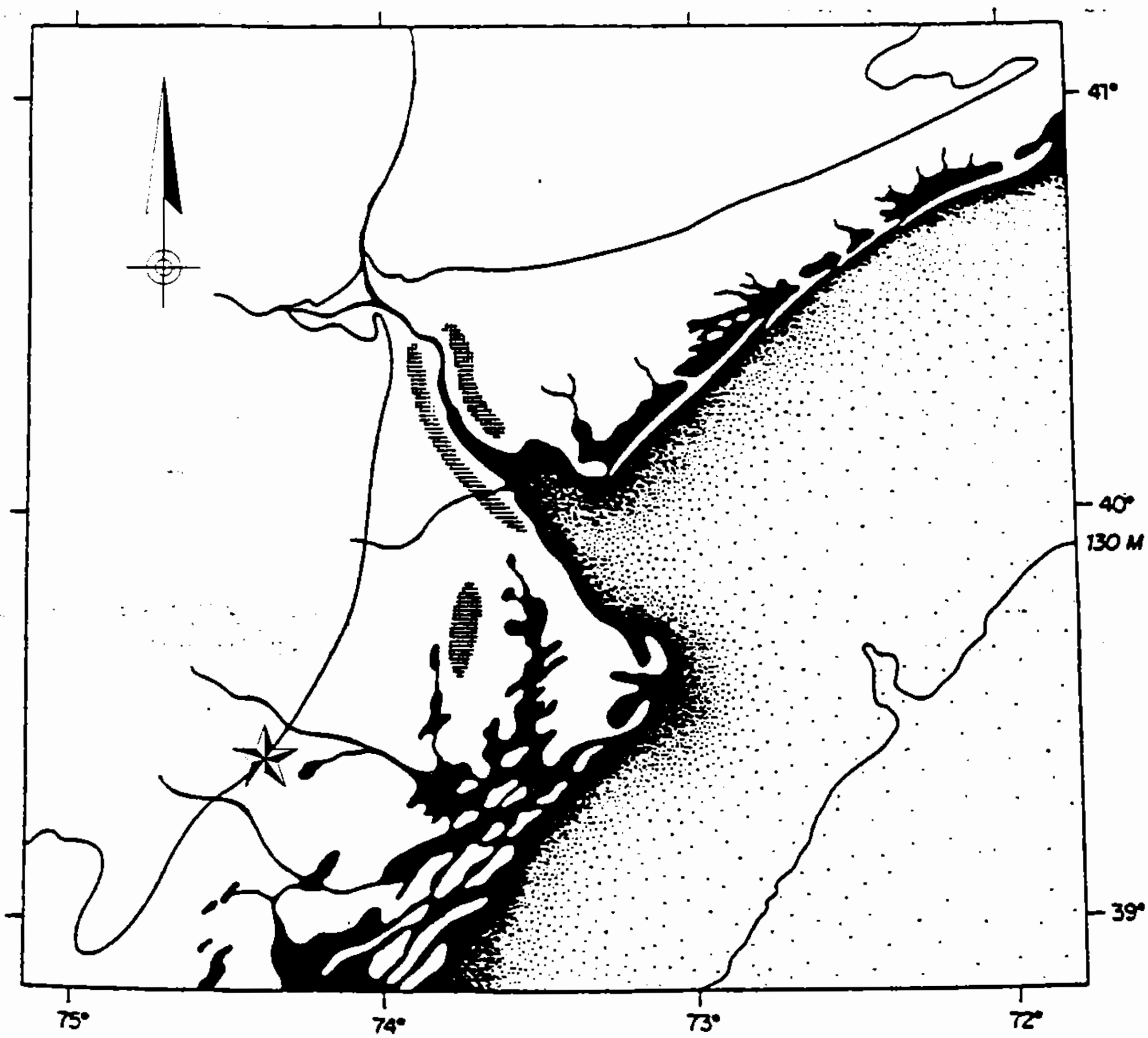

Figure 3.4. A Reconstruction of the Middle Atlantic Coastal Area 6,000 to 8,000 Years Ago (Source - Edwards and Emery 1977: Figure 7). The location of Absecon Beach is starred.

Climatic changes commencing about 4,600 years B.P. produced the warmest and driest conditions of the current post-glacial period, with oak and hickory becoming dominant tree species. These climatic changes appear to roughly coincide with the emergence of the archaeologically-defined Woodland I phase (Custer 1989). The Woodland I phase is typified by diagnostic lithic forms, an increase in base camps and the appearance of cache pits and ceramic storage vessels, indicative of a greater degree of sedentism. Evidence for long-distance trade/exchange is manifested in the presence of Adena material culture from the Ohio River valley at habitation and mortuary sites dating from around 2,500 to 2,000 years B.P. Increasing exploitation of estuarine resources is noted during the period of Adena influence.

The warm and dry climatic conditions began to yield to a cooler, moister modern climate with oak and chestnut vegetation about 2,000 years B.P., roughly coincident with the waning of Adena influence. By 1,000 years B.P. the trade and exchange network influence had disappeared, and the archaeologically-defined Woodland II phase emerges. Increasing evidence of sedentism is manifested in the expanded use of storage facilities and more permanent house structures. Increased gathering of shellfish and harvesting of plants reflect an intensification of food procurement evidently related to population growth. The emergence of agricultural production is also related to this sedentary settlement pattern which was maintained until European contact. Material culture is typified by distinctive ceramic forms and small triangular projectile points, the latter evidently indicative of bow-and-arrow technology (Custer 1989).

B. Study Area Prehistory

There are no reported sites within the current limits of the study area. Site maps and files of the New Jersey State Museum indicate that the closest known prehistoric sites are located more than three miles from Absecon Island in Pleasantville and near Linwood. Sites 28-At-3 thru 28-At-7 are all located near or within Pleasantville and were reported within the 1913 survey compiled by Alanson Skinner and Max Schrabish (Skinner and Schrabisch 1913). Site 28-At-3 was identified as an "old Indian village site." Artifacts discovered included some "fine bannerstones." Sites 28-At-4 thru 28-At-6 were reported by Leslie Spier and consisted of large shell heaps on the shore near Pleasantville. Spier also found projectile points at Site 28-At-7, which she identified as a camp site. To the southwest of Pleasantville is an aboriginal site located in Linwood, at the intersection of Seaview Avenue and Franklin Avenue. A surface collection of the site produced several projectile points and utilized flakes.

CHAPTER 4

HISTORICAL BACKGROUND

A. Historical Overview of Absecon Island

Up until the mid-19th century, when Atlantic City first emerged as a municipal entity in its own right, Absecon Island was divided into two separate coastal barrier landforms, separated by a small channel referred to as Dry Inlet. Dry Inlet was filled in the later 19th century, its location marking the approximate southern boundary of Atlantic City. The four municipal entities that presently make up Absecon Island were all originally part of Gloucester County, which was created in 1686. In the first municipal subdivisions of Gloucester County, which occurred in the early 1690s, Absecon Island was considered part of Egg-Harbour Township, also referred to sometimes as Great Egg-Harbour Township and New Waymouth. Egg-Harbour was formally incorporated in 1798 and in 1837 was included as one of the founder townships in the newly created Atlantic County. Atlantic City was set up at the northeastern end of Absecon Island and on adjacent sections of beach and marshland from parts of Egg-Harbour and Galloway Townships in 1854, with the remainder of the island being sectioned off around the turn of the century to Longport Borough [1898], Ventnor City [1903] and Margate City [1909] (English 1884; Snyder 1969).

European settlement in the Absecon Island vicinity was informally initiated by Swedish pioneers in the mid-17th century. The first settlement locus was within 20 miles of what is now Atlantic City, at Lower Bank, a hamlet on the north side of the Mullica River in present-day Burlington County. Esic Mullica, who came to the New World aboard the Key of Camar or the Guffin, reportedly settled at this latter spot in 1637 or 1638, finding no need at this early date to acquire formal title to land that was arguably part of New Sweden, New Netherland or the holdings of the English Crown. Following the overthrow of New Sweden by the Dutch, and then, in 1664, the English take-over of New Netherland, this section of New Jersey was granted to the Duke of York, who in turn conveyed what was then termed the province of West Jersey to John, Lord Berkeley. From this period, there are sporadic references to the name "Mullica" in the vicinity of Lower Bank (English 1884).

The first formal land surveys in the vicinity of Absecon Island were conducted at the end of the 17th century. In 1695, for example, Deputy Surveyor Worlidge ran a number of surveys along the New Jersey coast for Daniel Cope, Thomas Budd and John Budd. In a survey for Thomas Budd, dated October 11, 1695, Absecon Inlet is referred to as "Graverads Inlet" (English 1884). The region soon developed a strong shipbuilding tradition. Whaleboats were built in the area prior to 1700 and various types of fishing vessels were also being constructed before the 18th century. Census records indicate that by 1850 shipbuilding was the leading "mechanical business," being conducted principally at Absecon, Bakersville, Leedsville, Mays Landing, Tuckahoe and Port Republic. In all these towns, the small schooner was the leading type of ship built, being especially well suited for the trade in lumber and charcoal cut and burned in the interior (Wilson 1964a).

Prior to the completion of the Camden and Atlantic Railroad in 1854, Absecon Island itself remained largely undeveloped. It was owned by the Leeds family for much of the 19th century, with Jeremiah Leeds making his first purchase there in 1804. Subsequently, he and other members of his family added to the original holding. In 1816, Leeds leased to John Bryant a tract of land at the end of the island, "with the privilege of erecting a dwelling house and salt works and of pasturing two cows and a team for the works" (Wilson 1964b:527).

Jeremiah Leeds died in 1830, but his heirs kept title to the land until early in the 1850s, when the Camden and Atlantic Railroad Company began to buy up tracts on the island in anticipation of resort-based residential development. The railroad purchased 200 acres for 17 dollars an acre and a right-of-way 100 feet wide. The latter alignment is today followed by Atlantic Avenue. The Camden and Atlantic Railroad completed the rail connection from Camden to Absecon in 1854, and in the following year, a bridge was completed connecting Absecon to the barrier island on the shoreline. This enabled trains to reach the coast and set the scene for the development of the community of Atlantic City. At the time of the completion of this first railroad, Absecon Island was described as a "succession of barren sand hills and unproductive swamps." A second railroad, the Philadelphia and Atlantic Railroad, was completed to Atlantic City, by way of Pleasantville in 1877. The third and final railroad to reach Atlantic City was built in 1880 by the Pennsylvania Railroad and connected to Newfield via a branch from the West Jersey Cape May Line (Wilson 1964a:44).

The impact of the railroads on the shore economy was dramatic. The multiple rail access effectively enabled Atlantic City to emerge as New Jersey's premier resort location. Prior to the opening of the first railroad, Absecon Island was home to fewer than half a dozen families and there were only six structures in existence on the island. By 1859, the new resort town had 130 buildings, including a number of boarding houses, three churches, a schoolhouse, a market and a lighthouse. Census records indicate a population of 700 in 1860; by 1900, this had mushroomed to 28,000 (Wilson 1964b).

Contemporary maps give a clear impression of the rapidly growing community of Atlantic City at different times during its initial period of expansion. The Beers map of Atlantic County in 1872 (Figure 4.1) and a coastal chart prepared by the U.S. Coast and Geodetic Survey in 1879 (Figure 4.2) both show that, in the 1870s, all the development was confined to the northeastern end of the island. The Beers map further shows the broad undeveloped expanse of Absecon Beach extending to the southwest, interrupted only by two lifesaving stations, named New Inlet

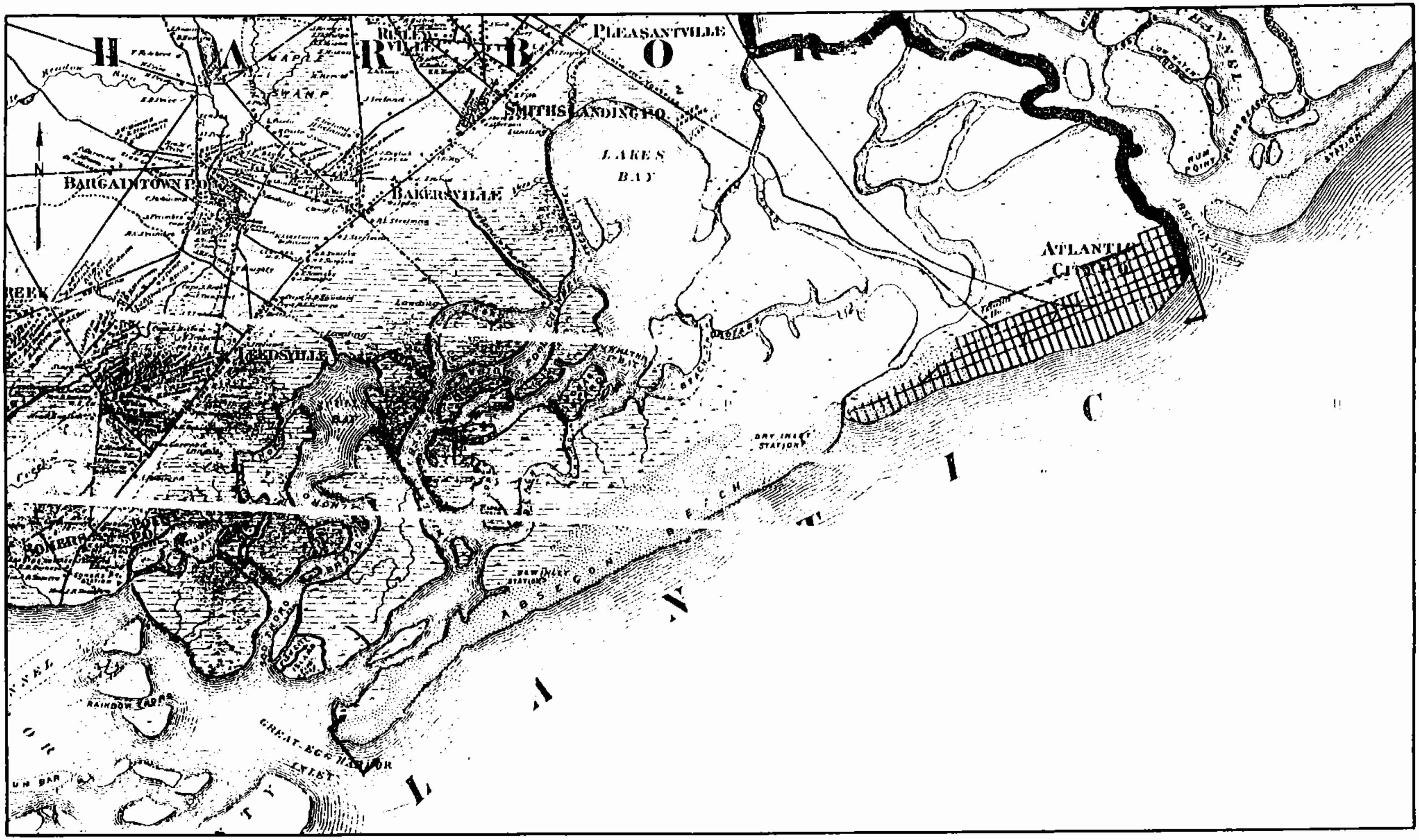

Figure 4.1. Beers, F.W. Map of Atlantic County, New Jersey. 1872. Scale 1 inch: 4,000 feet (approximately). Absecon Island shoreline indicated by arrows.

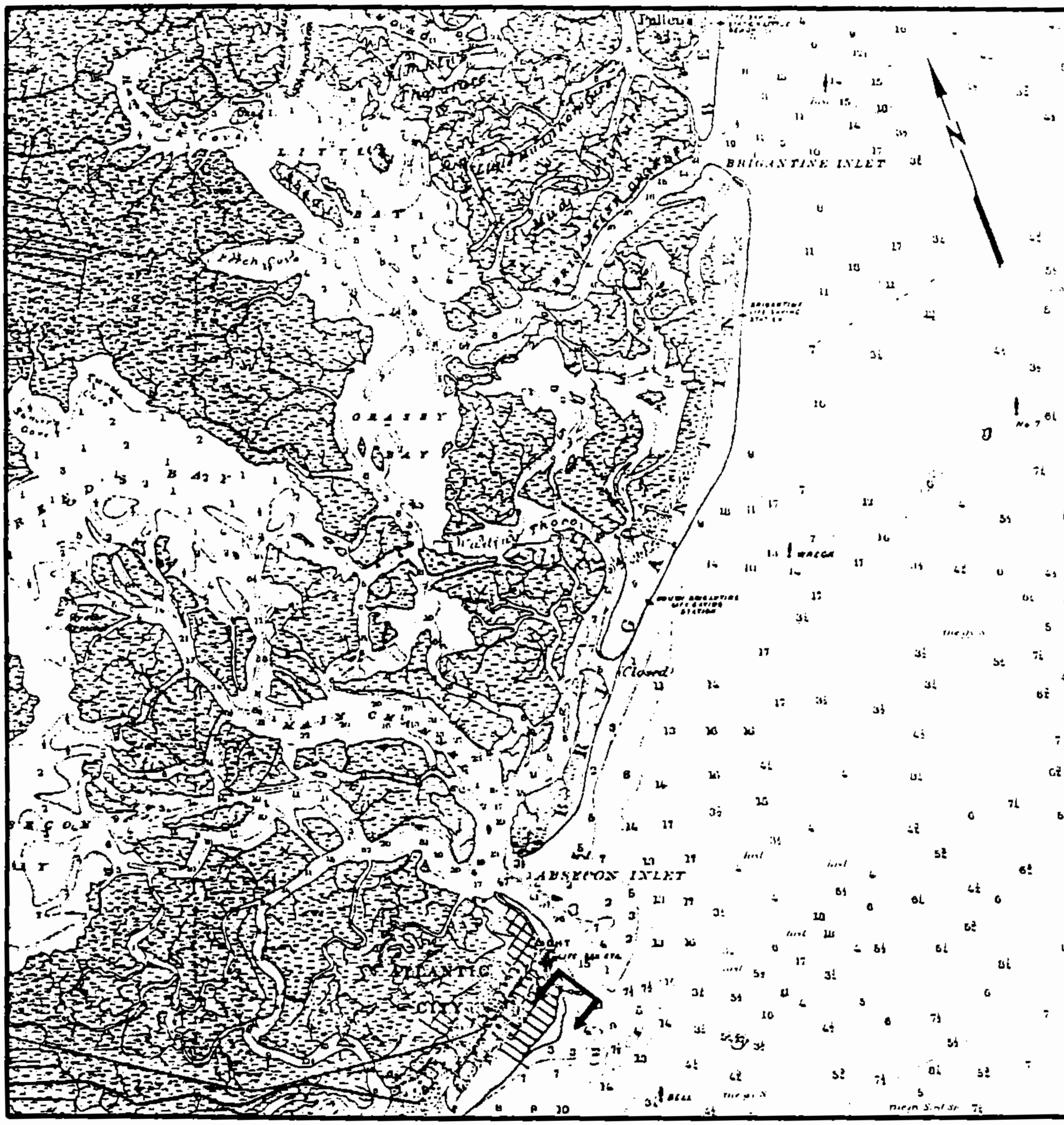

Figure 4.2. U.S. Coastal & Geodetic Survey. Coast Chart No. 122: Barnegat Inlet to Absecon Inlet, New Jersey. 1879. Scale 1 inch: 6,500 feet (approximately). Northeastern end of Absecon Island shoreline indicated by arrows.

Station and Dry Inlet Station. The Vermeule map of the Egg Harbor vicinity in 1891 (Figure 4.3) displays the considerable progress in development over the preceding two decades. The South Atlantic Railroad had been constructed along the length of the island spurring settlement growth in two new locations: Longport (near the southwestern tip of the island) and South Atlantic (in what later became known as Margate City). By the turn of the century, as seen in Vermeule's Geological Survey map of New Jersey, Atlantic City Sheet, prepared in 1902 (Figure 4.4), both Longport and South Atlantic City had expanded to the point that there was virtually no undeveloped land between the two. To the northeast, the city of Ventnor had been established, and Atlantic City itself was being steadily extended southwestward towards this new focus. Most of the development in the three communities lying to the southwest of Atlantic City, extended inland only for some 2,000 to 3,000 feet to the edge of the marshlands separating the Absecon Island from the mainland. Ventnor extended to what was being called the Inside Thorofare.

The remaining paragraphs of this section of the chapter are devoted to some of the principal shoreline features of Atlantic City itself, notably the boardwalk, the piers and their attendant recreational facilities. The original idea for the Atlantic City boardwalk dates to 1870. Since most of the hotels lacked extensive carpeting, beach sand was continually being tracked in by tourists, destroying the hotels' wooden floors. On May 9, 1870, the City Council passed a resolution to build the first boardwalk. This structure was built in elevated sections 18 inches above the sand, and could be disassembled and put in storage during the winter months. In 1884, the first permanent boardwalk was erected. It stood five feet above the beach and was 20 feet wide. It also was the first such structure to be equipped with electricity. The present ocean-front structure, composed of steel pilings and steel girders, is the fifth boardwalk, and was built by the Phoenix Bridge Company in 1939 (Cunningham 1978:249; University of Pennsylvania et al. 1980).

As early as the 1880s, the prospect of entertainment piers extending from the boardwalk out into the sea was envisioned. The Central Pier, the Steeplechase Pier and the Steel Pier were the first of these piers to be built. The current two-story Central Pier replaced an earlier pier, called Young's Pier, which was built in the 1890s. Young's Pier was destroyed by a storm and in 1922, the Central Pier Company bought the property and built the present structure. The Steeplechase Pier was first named the Auditorium Pier, when it was constructed in 1899. Initially, it was connected to the boardwalk by a wooden walk from the beach. Later, the pier itself was extended to meet with the boardwalk. It was rebuilt in 1904 to include a bandshell, so that music could be heard from the boardwalk, at which time it was renamed the Steeplechase Pier. In 1932 it was completely destroyed by fire, but was rebuilt in the same year. In the 1960s it was the first amusement pier to reintroduce the roller coaster as an attraction. The Steel Pier was also constructed around the turn of the century (University of Pennsylvania et al. 1980). All three of the piers are shown on the Vermeule map of 1902 (Figure 4.4). The map shows three additional piers, one to the northeast closer to the Absecon Lighthouse and the other two are located between 3,000 and 4,500 feet to the southwest.

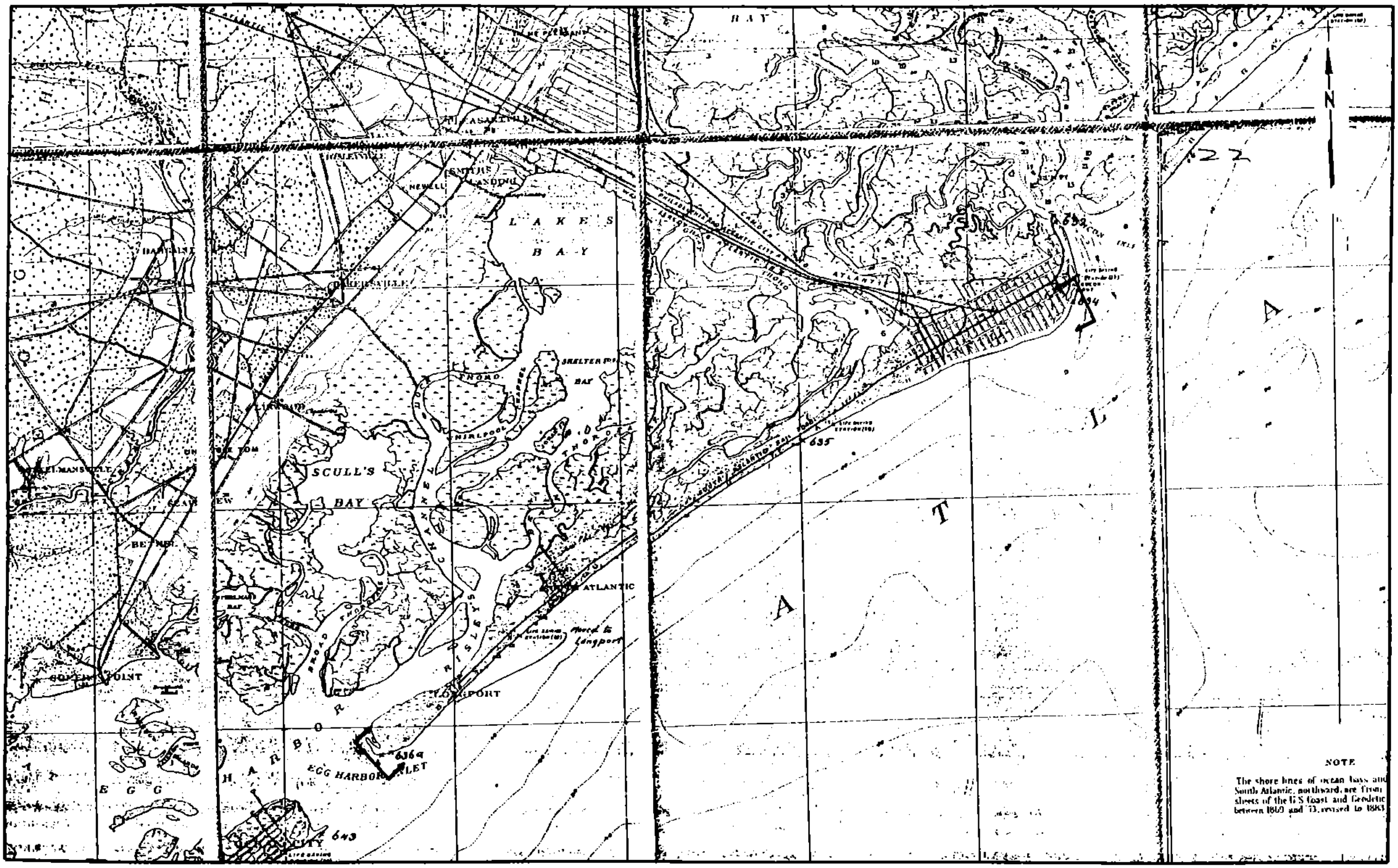

Figure 4.3. Vermeule, C.C. Topographic Map of Egg Harbor and Vicinity including the Atlantic Shore from Barnegat to Great Egg Harbor. 1885. Scale 1 inch: 5,000 feet (approximately). Absecon Island shoreline indicated by arrows.

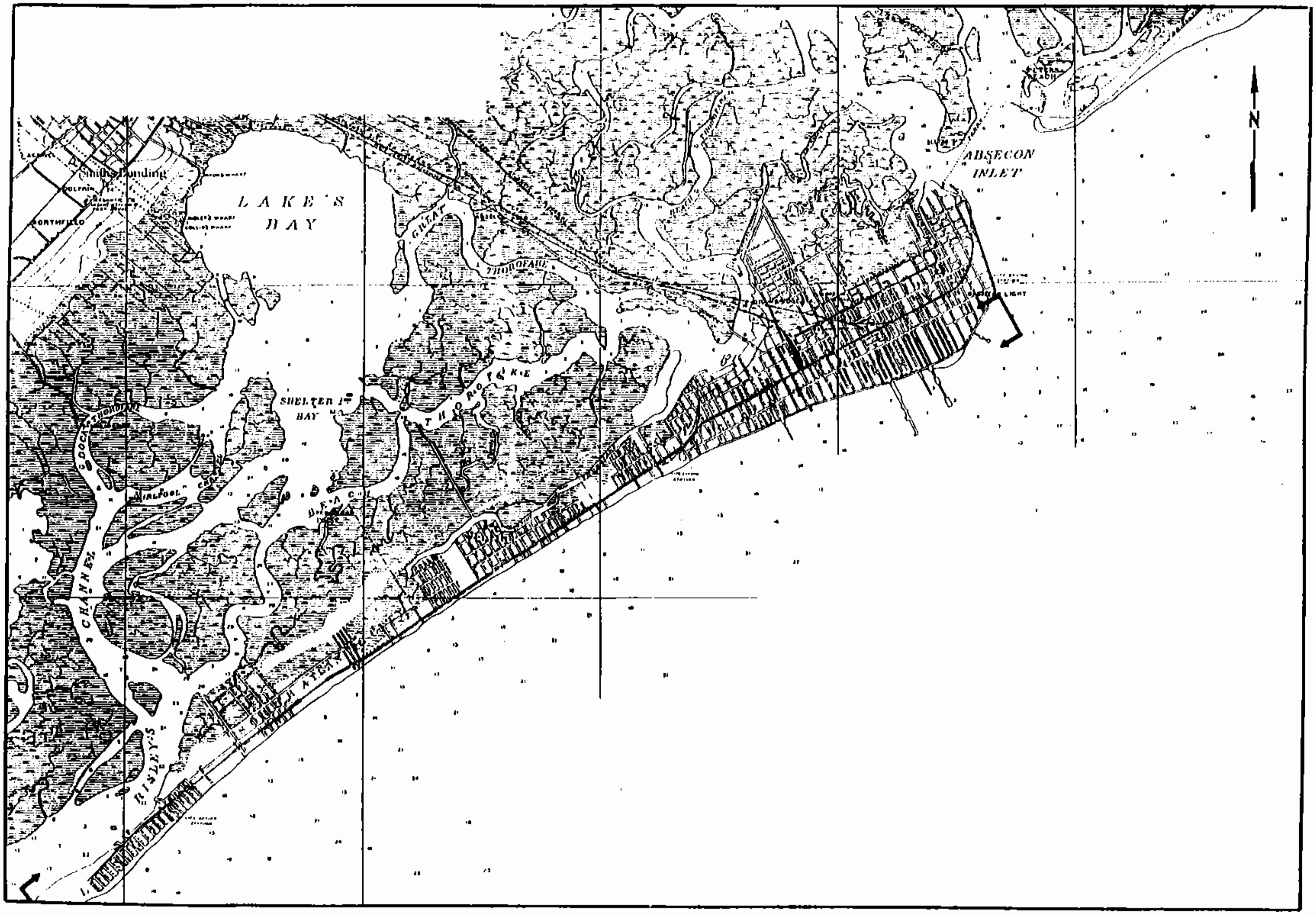

Figure 4.4. Vermeule, C.C. U.S. Geological Survey of New Jersey. Atlantic City Sheet. Surveyed in 1883, re-surveyed in 1900, edition of 1902. Scale 1 inch: 4,000 feet approximately). Absecon Island shoreline indicated by arrows.

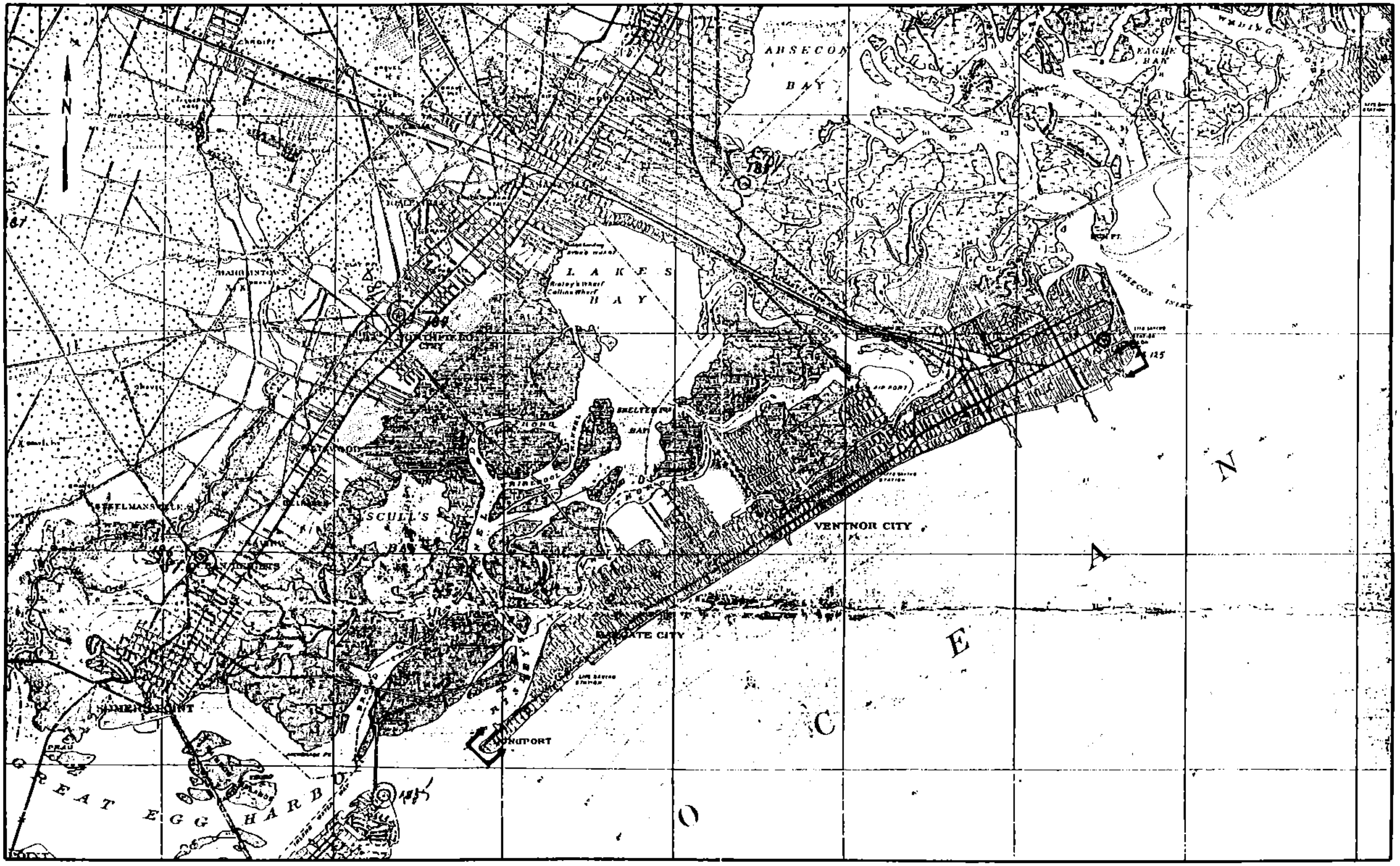

Figure 4.5. State of New Jersey Department of Conservation and Development. Atlas Sheet No. 36. Originally surveyed 1883-84, principal features revised 1916 and 1933, edition of 1934. Scale 1 inch: 1 mile. Absecon Island shoreline indicated by arrows.

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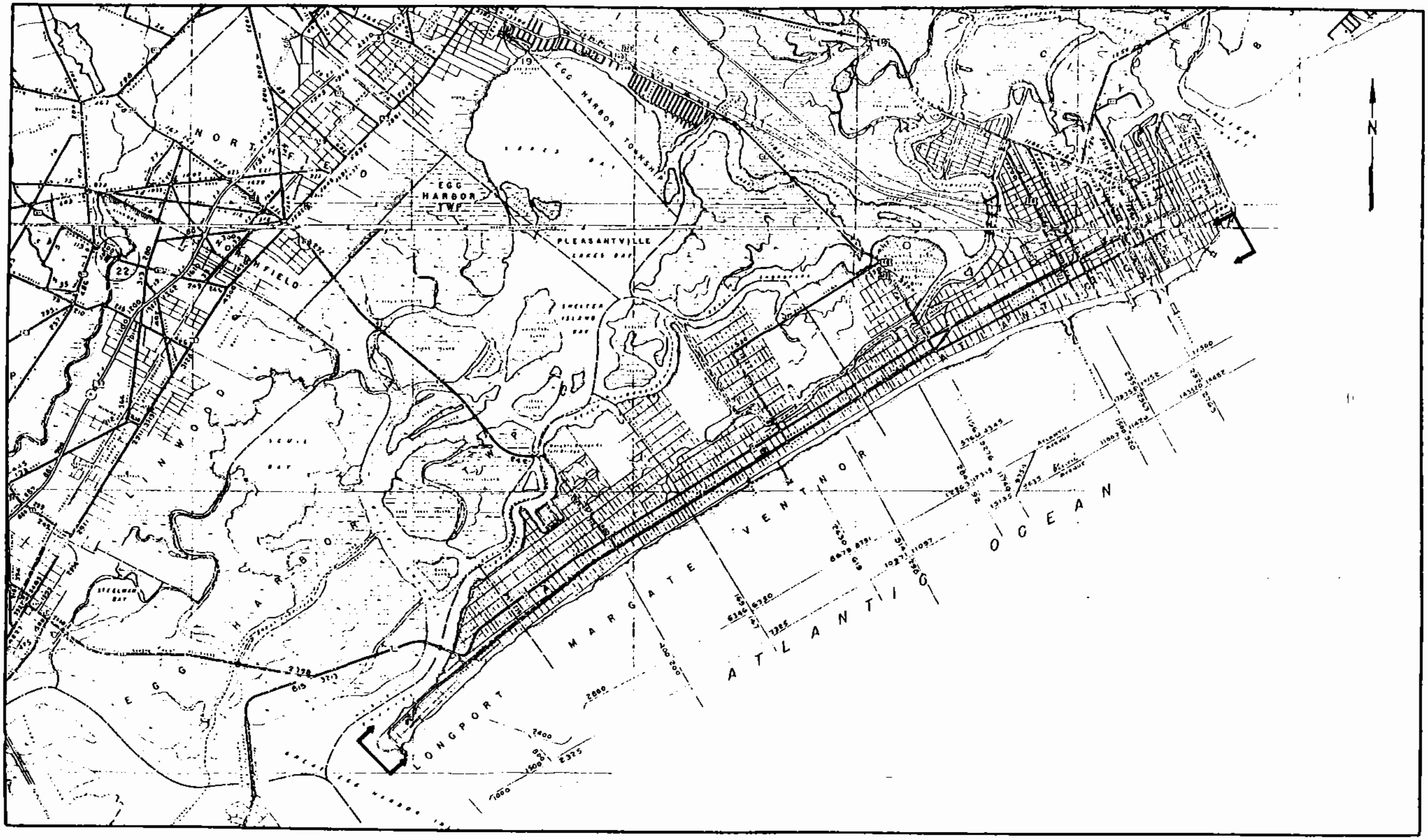

Figure 4.6. New Jersey State Highway Department. Base Map of Atlantic County, New Jersey. 1941. Scale 1 inch: 4,000 feet. Absecon Island shoreline indicated by arrows.

The Garden Pier was built between 1912 and 1914, and supported 25 stores and a large four-towered building containing a ballroom, a theater and an exhibition hall. All of these buildings were centered around a garden court, from which the pier derives its name. In 1940, after years of financial problems, the city took possession of the pier and made plans to convert it into a new civic center. It was nearly 15 years before the project actually took place (University of Pennsylvania et al. 1980). The Department of Conservation map of 1934 (Figure 4.5) and the New Jersey State Highway Department Base Map of Atlantic County in 1941 (Figure 4.6) both show the Garden Pier as well as the Million Dollar Pier (present-day Ocean One Mall). These maps also indicate that by the inter-war period time the development of Absecon Island had been extended to its current limits with the aid of much land reclamation and filling in the back bay area.

From the third quarter of the 19th century into the first quarter of the 20th century, the Atlantic City resort community prospered mightily. In 1920, the Convention Hall was opened in celebration of the city's 75th birthday and for many years the Convention Hall has been the National Headquarters of the Miss America Pageant. As the automobile became the preferred mode of personal travel, private companies constructed toll roads and bridges connecting Absecon Island with Ocean City to the southwest, Northfield to the northwest, and Brigantine Beach to the northeast.

The surging economy of Atlantic City encountered its first major setback when the stock market crashed in 1929. Twenty-eight banks were closed and the number of visitors and vacationers dropped dramatically. The city was devastated and, to this day, has yet to fully recover its former glory as the jewel of the nation's east coast resorts. During World War II hundreds of soldiers arrived and took over the hotels, first using them as barracks and then as hospitals. It was not until after the war that the city began to regain its momentum, and between 1948 and 1963, the city replaced many of its old hotels with new motels. The local economy was bolstered only temporarily, however, and the city is currently relying on the recently permitted introduction of casino gambling as the basis for its revival (Cunningham 1978: 250-252). However, despite the increasing popularity of the casinos over the past two decades, Atlantic City's permanent population has been in steady decline, while that of the neighboring towns of Ventnor, Margate and Longport has been increasing.

B. Maritime History

Absecon Inlet was concurrently developed as the harbor for Atlantic City in the late 19th century. Although merchants in the region had long used the Absecon Inlet to transport lumber, ice, coal, brick, stone, oysters and other items to and from the various beachfront and interior communities, by the end of the 19th century the inlet was principally being used by pleasure and fishing craft. Despite this increasing use by small vessels, navigational improvements to the inlet were not completed until near the end of the 19th century, and navigation through the high-energy environment of the inlet remained treacherous throughout this period. Coastal storms rapidly moved sand in the vicinity of the inlet, alternately shoaling and eroding the channel through the inlet. In response to growing concerns by local merchants and sea captains, the U.S. Army Corps of Engineers surveyed the inlet, constructed a jetty on its northeast side to stabilize the channel, and authorized an initial navigation improvement project to maintain the channel at a depth of 12 feet (U.S. Army Corps of Engineers 1911).

Although there are no major ports to speak of along New Jersey's Atlantic coast, there has been a consistently high volume of ship traffic passing up and down the coast en route to the port cities in New York Bay and Delaware Bay throughout the historic period. The barrier beaches and inlets along the 127-mile New Jersey coastline offer little relief to mariners in distress. There were few options available to captains of vessels that were caught in squalls off the central portion of New Jersey's Atlantic coast. Absecon Inlet was one of only a few suitable harbors in which to seek refuge. Entering the inlet during a coastal storm was quite hazardous, however, and of the hundreds of vessels lost during storms along the New Jersey coast, a number have been documented as being lost in the vicinity of Absecon Inlet.

Despite the increasing number of ship losses along the coast of New Jersey (and elsewhere along the Atlantic coast of the United States), federal funding of aids to navigation and lifesaving stations in New Jersey did not occur until the 19th century. The first aid to come from Congress was in 1823, when an allocation was made for the construction of a lighthouse at Cape May. A lighthouse had been constructed previously on Sandy Hook in 1761, but this was financed by New York merchants, and only later was the facility acquired by the Federal government. Following the construction of the Cape May Lighthouse, a series of lighthouses were constructed along the New Jersey shoreline during the 19th century. In 1857 the Absecon Lighthouse was constructed at the northeast end of Atlantic City. This lighthouse, nearby lifesaving stations and the shoal waters blocking much of the entrance to Absecon Inlet are all illustrated on a U.S. Coast and Geodetic Survey Chart of this portion of New Jersey prepared in 1879 (see above, Figure 4.2).

Lifesaving stations were also financed by the Federal government. In the first quarter of the 19th century, volunteer lifesaving stations were scattered along the New Jersey shore. Typically, these were manned by small bands of local fishermen. The first federal appropriation for lifesaving stations occurred in 1848 when $10,000 was set aside to provide lifeboats and rockets for the protection of life and property on the New Jersey coast from Sandy Hook to Little Egg Harbor. This was the first federal appropriation to any state for such work. Eight lifeboat stations were constructed as part of this program. In the following year, another appropriation was made for six stations between Little Egg Harbor and Cape May. By 1872, stations had been established on the average of every five miles along the shore, and in 1886 the Federal Government inaugurated the policy of manning all stations with paid crews (Wilson 1964a). By 1900 there were 42 lifesaving stations on the New Jersey coast at an average of three miles apart.

Absecon Island had three lifesaving stations. Lifesaving station records from 1886 to 1897 confirm that 139 vessels were in distress off the coast of Absecon Island during those 11 years (U.S. Army Corps of Engineers 1894). A topographical map of Egg Harbor and vicinity produced in 1891 (see above, Figure 4.3) shows that the three lifesaving stations from northeast to southwest were numbered 27, 28 and 29. Lifesaving station 27 was located at the northeastern tip of the island near the Absecon Lighthouse. Lifesaving station 28 was located almost a mile to the southwest of Atlantic City. The final station, lifesaving station 29, was located between Longport and South Atlantic City (present-day Margate City). Apparently this station was later moved to Longport as indicated by the notation.

CHAPTER 5

CULTURAL RESOURCES POTENTIAL

This chapter addresses in broad terms the potential for cultural resources within the proposed offshore sand borrow areas and along the tidal zone and shoreline of Absecon Island. First, potential survival of prehistoric and historic terrestrial resources, i.e., resources that were formed on land and have since been inundated by water or sediment as a result of rising sea level and other offshore depositional activity, is discussed. Second, the potential for underwater resources is examined, i.e., resources such as shipwrecks, downed airplanes or jetties, whose original formation occurred in a marine environment.

A. Submerged and Shoreline Terrestrial Resources

Much research has focused upon the geomorphology of Atlantic coastal regions (Emery and Milliman 1970; Kraft 1971; Sheridan et al. 1974; Belknap and Kraft 1977; Weil 1977; Kraft et al. 1979) and of the implications of geomorphological change for archaeological site preservation (Kraft 1977a; Belknap and Kraft 1981; Kraft et al. 1983). Stuiver and Daddario (1963:951) published five radiocarbon dates derived from peat deposits above basement surfaces at a series of increasing depths from the lagoon between the Brigantine City Barrier and the New Jersey mainland. These data indicated a submergent rate of three meters per millennium from 6,000 years ago until 2,000 to 3,000 years ago, when the rate slowed to 1.2 to 1.4 meters per millennium. More recently, Dr. Stewart Farrell, geomorphologist at Stockton State College, has examined radiocarbon samples from Absecon Creek near Absecon Town. These samples show a sea level rise of 5.5 meters in the period since the location was a freshwater cedar swamp 4,100 years B.P., thus indicating a mean rise of 1.3 meters per millennium (Farrell 1995: personal communication). However, evidence exists to indicate that sea level rise at a given locale was not a completely linear trend, but was to some degree cyclical and synchronized with fluctuating transgressive rises and regressive falls (Kraft et al. 1983:105).

As land environments are successively swallowed by coastal marshes, barrier beaches and ocean/bay waters, tectonic activity, related in the Middle Atlantic to the offshore Baltimore Canyon Trough geosyncline, and the potential "water loading" effect have resulted in a downward dip of stratigraphy below sea bottom (Kraft and John 1978:106) (Figure 5.1). Analyses of marine cores provide evidence of a transgressive sequence stratigraphy of sedimentary facies at increasing depths as one moves offshore: shallow fine marine sands at the top; coarser barrier sands; lagoonal muds, tidal salt marsh mud and peat; and Pleistocene land

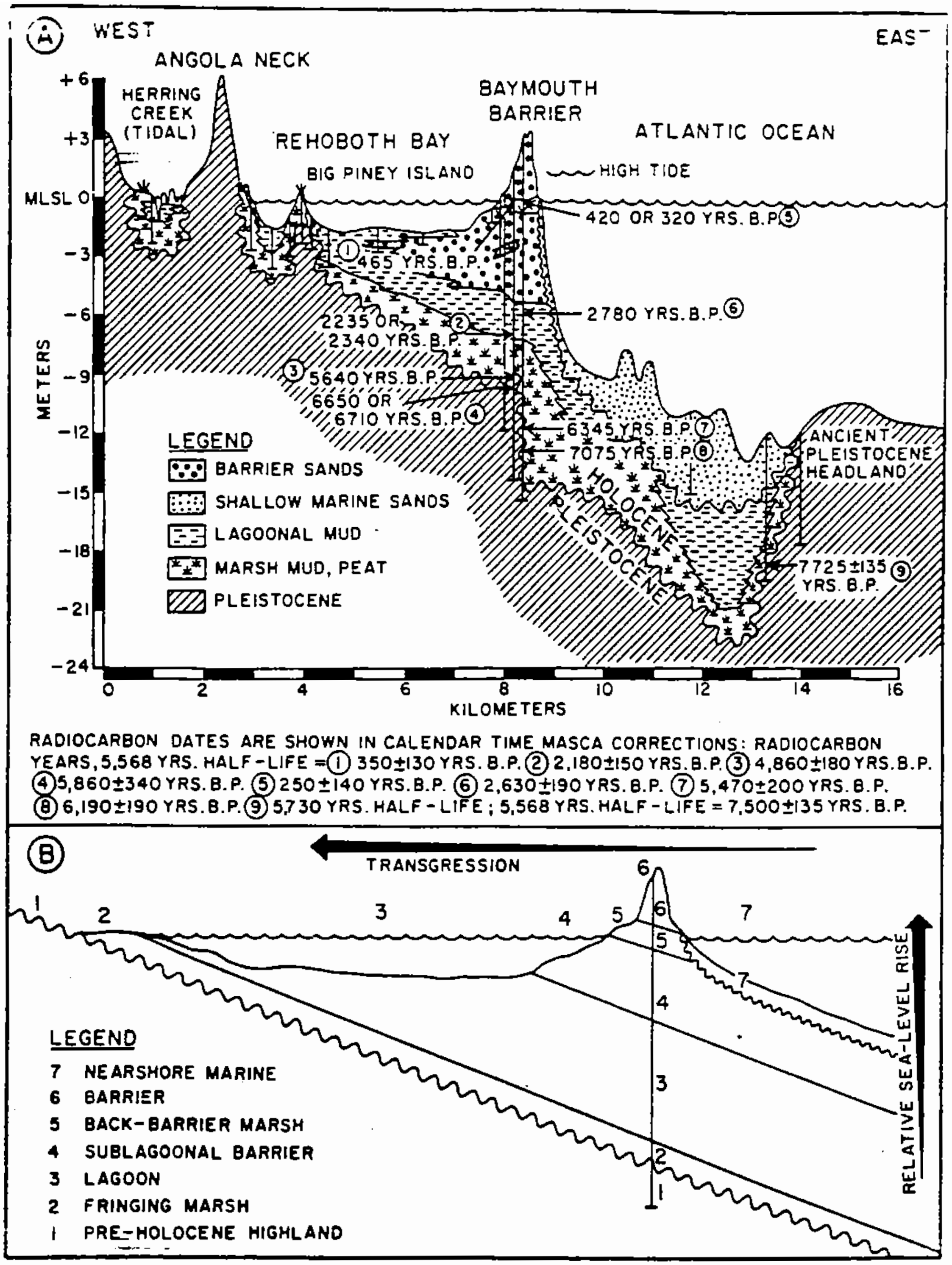

Figure 5.1. (A) A Geologic Cross Section across the Barrier Coast and Rehoboth Bay (Section line C on Figure 3.1). Note the similar sequence of geographical distribution of coastal sedimentary environments with the vertical sequence encountered in the drill boring. (B) A Schematic Illustration of the Nature of a Marine Transgression and Walther's Law of Correlation of Sedimentary Facies. Source - Kraft and John 1978:Figure 3.

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surface at the bottom. Radiocarbon data reflect a parallelism of sea level dates as depth increases relative to the modern Coastal Plain (Belknap and Kraft 1977: Kraft and John 1978:106). Kraft and John cite these coastal Delaware data as classic examples of Walther's Law of Correlation of Sedimentary Facies, by which the horizontal distribution of sediments in present geographic environments is expected to be reflected in a similar vertical distribution of sediments from environments moving through geologic time (1978:106-108).

Despite the horizontal movement of coastal environments, the sedimentary sequences discussed above indicate that the environmental structure and relative positions of environmental types have remained stable, i.e. as lagoon/barrier shorelines with fringing coastal marshes which often were cut by large estuaries of (presently drowned) rivers (Kraft et al. 1983:59). Kraft et al. (1983:111) emphasize that the preservation potential for a submerged archaeological site is a function of two principal variables: the pre-Holocene topography on which the site was deposited, and the rate of sea level rise.

Figure 5.2, taken from Kraft et al. 1983: Figure 8, illustrates the potential impact of changes in coastal geomorphology upon archaeological site preservation. The bold arrows indicate areas of ideal site discovery potential beneath marine sediments. These locations occur along the flanks of former interfluves which lie below the marine eroded zone, yet are still shallow enough to be accessible (Kraft et al. 1983:112). Other site preservation scenarios are also considered in this illustration. Site 1, a headland site near a freshwater source, is based upon the Woodland mortuary site of Island Field in Delaware; continued landward migration of the coastal barrier and sea would most likely consume this locus. Site 2, a shell midden at the edge of a marsh and lagoon may conceivably be preserved in the marsh/lagoon mud facies below a rising sea level. Site 3 would have originated adjacent to an estuary or tidal river. Due to the delay between burial and arrival of the eroding shoreline, it would become more deeply buried and stand a greater chance of survival, although its accessibility is reduced (Kraft et al. 1983:110-111).

Various examples of submerged terrestrial resources which have survived inundation processes may be cited. Inundated karst formations in Sarasota County, Florida, and in the Gulf of Mexico off Fort Myers have produced evidence of prehistoric human occupation (Ruppe 1979). These examples reflect, however, the effects of geomorphological processes within the Gulf of Mexico -- effects which are somewhat less dramatic than those encountered along the Atlantic coast. Clearly, the research of Kraft and others along the Delaware coast demonstrates that the study of coastal geomorphology and environments is capable of providing useful insights into the nature and condition of submerged cultural resources that may exist. It is also evident that the inundation of prehistoric and early historic archaeological sites may result in extensive resorting or removal of the archaeological record. Furthermore, while isolated artifacts preserved in the bottom sediments could survive in an excellent state of preservation, the associated context of human activity may have been destroyed. The high energy environments that are often present along ocean coastlines will lessen the likelihood that fragile evidence of prehistoric occupations would survive.

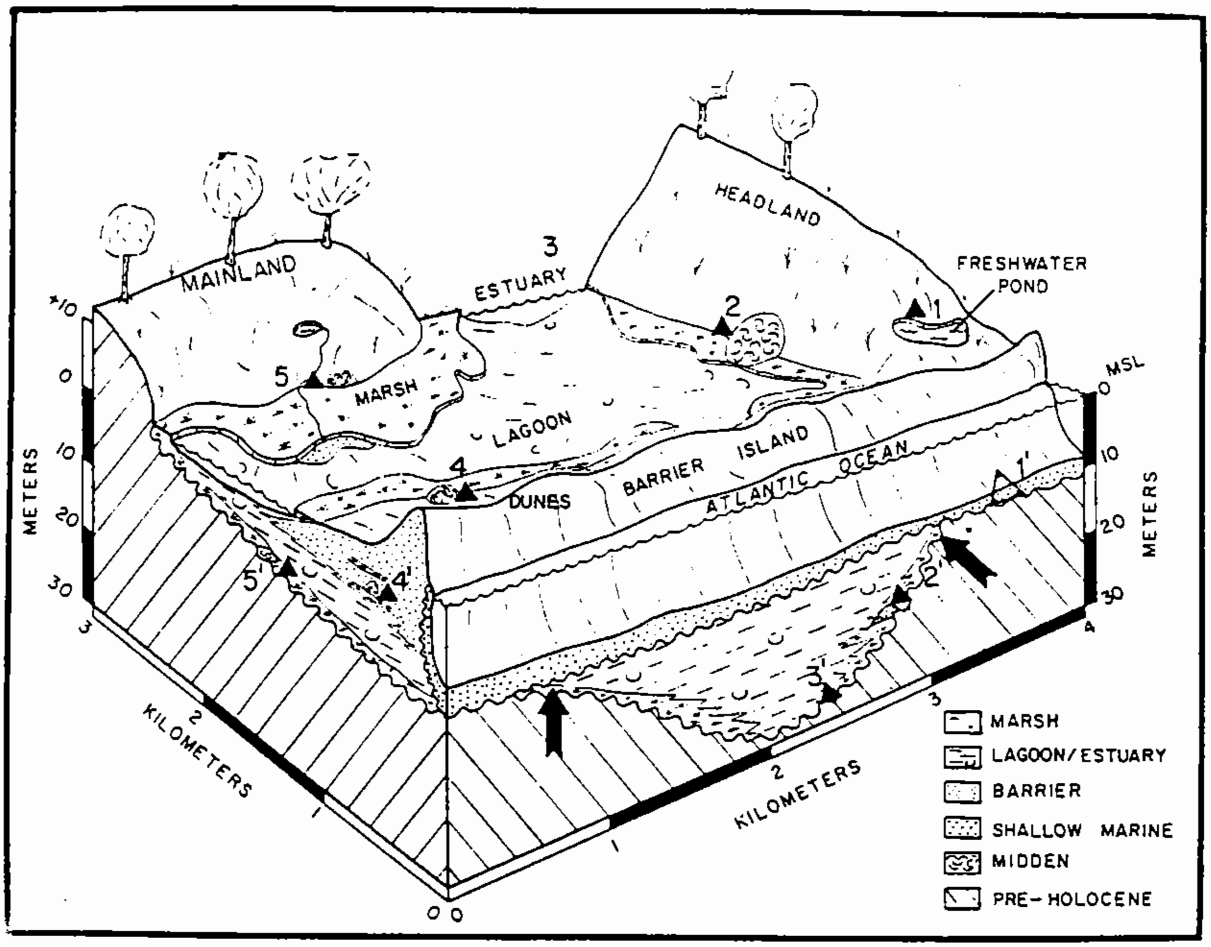

Figure 5.2. Block Diagram Illustrating Geologic Setting of Coastal Archaeological Sites in Delaware. Site numbers 1-5 indicate original environments of deposition; numbers 1'-5' reflect the geological settings of those sites after sea-level rise, coastal inland movement and/or burial beneath sediments. Source - Kraft et al. 1983:Figure 8.

In addition to the relatively few documented occurrences of inundated terrestrial resources, considerable effort has been expended over the past quarter century in attempting to develop effective predictive models that can guide researchers intent on locating submerged prehistoric resources and assessing site preservation potential. Much of this work has taken place in the Gulf of Mexico and along the Atlantic Continental Shelf in connection with offshore gas and oil leasing activities (e.g., Coastal Environments, Inc. 1977; Bourque 1979). For the most part, these studies conclude that paleogeographic analysis (with particular reference to sea level change and coastal geomorphic processes), coupled with remote sensing and selective core sampling, can assist in narrowing down offshore areas where site preservation potential is high. As just one example, although the location and identification of submerged Archaic sites would be difficult, their association with shell middens should increase the chances of their being detected. Indeed, investigations in the Gulf of Mexico off the west coast of Florida have confirmed both the association of prehistoric material with submerged middens and the detectability of these sites using side scan sonar remote sensing (Ruppe 1979).

The macro-scale model-building studies noted above are valuable as an overall guide to preservation potential of terrestrial resources within large expanses of ocean, but they tend to be too broad and generalized for effective application in the study of small offshore tracts such as those proposed for sand borrowing of the Jersey coast. The need for detailed, local paleogeographic data will always be paramount for site-specific offshore studies, and in most instances, such data are not readily available, and are both expensive and logistically awkward to derive and interpret.

B. Underwater Resources

As with inundated terrestrial resources, the effect of coastal geomorphic processes may either erode or bury underwater resources, and the processes may occur rapidly or slowly over time. However, because of the "accidental" and rapid manner in which many underwater resources (notably shipwrecks) are formed, and the shorter elapsed time involved before their remains are sought, they are frequently better preserved and generally more easily discovered. Underwater resources, such as shipwrecks, because they usually constitute a stronger physical (topographic, magnetic) anomaly than most inundated terrestrial resources are also far more easily identified by remote sensing techniques involving the use of magnetic, acoustic or sonar detection equipment.

In many cases, the remains of shipwrecks may be submerged, but not buried beneath sediment. Shipwreck material deposited in even the shallowest environment can settle rapidly into the bottom with its associated archaeological record intact. The wreck of the Sindia (1901), discovered in the surf zone near the foot of 17th Street, Ocean City provides a good example. A good portion of the lower hull survived intact, along with an extensive associated artifact assemblage (Seibold and Adams 1986). Even in extremely high-energy environments, evidence of the ship structure frequently survives. A recent discovery of a wooden hull sailing vessel adjacent to the Showboat Casino, Atlantic City, also confirms that vessels have survived the inundation process near the project vicinity (Correspondence files held by the New Jersey Historic Preservation Office). Numerous other archaeological investigations off the coasts of the states of Massachusetts, North Carolina, Florida and Texas, and the countries of England, Israel and Turkey, offer examples of ship remains with valuable archaeological data that have survived.

At many shipwreck sites, sand and light mud similar to the bottom sediments in portions of the study area have provided an excellent environment for preservation. Given the level of maritime activity near Absecon Inlet, the extent of vessel losses in this general vicinity, and the level of preservation at shipwreck sites in other similar environments, it is highly possible that well-preserved shipwreck sites could exist in the vicinity of the study areas. However, any potential shipwreck sites would be almost certainly buried by an extensive amount of sand. Wrecked vessels typically act to trap sand, particularly in an environment where strong longshore currents transport high volumes of suspended sand up and down the coast. On the other hand, buried wreck sites sometimes become exposed again, as severe coastal storms may also erode the sand which encapsulates most wreck sites.

In conjunction with exploration, colonization and the expansion of coastal commerce, New Jersey's Atlantic coast has become a repository for submerged cultural resources. Many types of ships and vessels have been wrecked while passing up and down the coast en route to port destinations along the seaboard. Many vessels attempting to reach protected waters within Absecon Inlet, have instead been wrecked on the Brigantine Shoals, which partially obstruct the entrance to the inlet. With periodic strong coastal storms (often with treacherous northeast winds), the presence of shoals and swift tidal currents, and the historically heavy volume of coastal traffic, the Absecon Inlet vicinity has become the documented final resting place for more than a hundred sailing vessels, steamships, barges, tugs and modern ships that have been lost over the last three centuries.

A recent Bureau of Land Management study of the Continental Shelf from the Bay of Fundy to Cape Hatteras has characterized the New Jersey Coastal Zone as an area of "moderately heavy" predicted shipwreck density (Bourque 1979). An inventory of shipwrecks and all types of ship losses near Absecon Inlet was compiled during the background research phase of this study (Appendix A). Drawn from a variety of primary and secondary sources, this extensive shipwreck list, while far from comprehensive, provides some indication of the wide variety of shipwrecks that have been lost near the project vicinity over the last 300 years. More than 130 shipwrecks and ship losses were documented in Absecon Inlet since the first reported loss in 1775. Although there are no documented underwater resources within the boundaries of the two proposed sand borrow areas, Appendix A and secondary and primary historical sources show that numerous vessels have been deposited in the general vicinity of the project areas throughout the historic period. The study area is therefore considered on the basis of background research to hold a high potential for yielding underwater resources of a caliber suitable for inclusion in the National Register of Historic Places.

Based on the information in Appendix A, the types of underwater resources that may be present in the Absecon Inlet vicinity include a variety of materials dating from the early 17th century through the Second World War. Potential vessel types include wrecks representative of all phases of commercial and naval activity taking place along the New Jersey portion of the Atlantic Coast. Wood-hulled ships, ranging from small fishing sloops, shallops, recreational sailing and motor craft, and coastal schooners, to sail-rigged warships, have been lost along the New Jersey Atlantic Coast. Iron-hulled vessels, including paddle wheel steamboats and World War II-era merchant ships sunk by German submarines, have also been lost in the project vicinity. Large 20th-century steamships are also among the listed losses in the region. Many of these types of vessels would potentially provide insight into a wide range of maritime-related topics, including the contexts of naval activity, shipbuilding, regional shipping, and patterns of trade and industry.

CHAPTER 6

SURVEY INVESTIGATIONS

The purpose of the fieldwork component of these cultural resources investigations were twofold: to conduct a visual inspection of the tidal zone and shoreline of the eight-mile section of Absecon Beach for evidence of potentially significant cultural resources; and to carry out a comprehensive remote sensing survey within two proposed offshore sand borrow areas in the Atlantic Ocean. The major work effort was directed at the latter underwater archaeological survey, the purpose of which was to locate, identify and preliminarily assess the significance of submerged prehistoric and historic resources that might be affected by future dredging activity. The underwater survey was designed to generate sufficient magnetic, acoustic and bathymetric remote sensing data to identify anomalies caused by submerged cultural resources. Analysis of the remote sensing data aimed to isolate targets of potential historical significance that might require further investigation or avoidance. No diving was undertaken on these targets.

A. Terrestrial Survey

Field investigation along the eight-mile section of the Absecon Island tidal zone and shoreline was completed by two archaeologists at low tide on August 31 and September 13, 1994. In addition to inspecting and photographing the waterfront, project staff asked local residents whether they had any knowledge of buried or submerged cultural resources along the Absecon Island shoreline.

The field investigation and associated interviewing of local residents failed to identify any evidence of prehistoric resources within the eight-mile beach segment. Historical architectural resources previously identified along the shoreline, from south to north, consist of: the Margate Pier; the Ventnor City Fishing Pier; the Ocean One Mall (formerly the Million Dollar Pier); the Central Pier; the Steeplechase Pier; the Steel Pier; and the Garden Pier. In addition, there are numerous structures (e.g., jetties, groins, and frames for outflow pipes) that have been constructed perpendicular to the waterfront along Absecon Beach. Groins and jetties were placed along the shoreline in an effort to arrest ongoing problems with sand eroding from the beach. Apart from the structures noted above, these investigations failed to identify any evidence of buried or submerged cultural resources along the shoreline. A list of the objects identified during the shoreline survey is included in Appendix B.

B. Underwater Survey

1. Field Survey and Analytical Procedures:

All remote sensing fieldwork was carried out from a 25-foot survey vessel suitable for open and shoal water operations. A *Geometrics,* G-866, proton precession magnetometer, capable of +/- one gamma resolution, was employed to collect magnetic remote sensing data. A two-second sampling rate by the magnetometer's towed sensor, coupled with a 3.5- to 4-knot vessel speed, assured a magnetic sample every ten feet. A *Klein* two-channel acoustic recorder with a 500 kHz side scan sensor was used to collect acoustic data. Acoustic data was recorded on wet chemical paper with an analog recorder. An *Odem* Echotrac precision depth sounder with a narrow beam transducer was used to collect bathymetric data.

Survey vessel trackline control and position fixing were obtained by using a laptop PC-based software package *(Hypack)* in conjunction with a *Navstar* Differential Global Positioning System (DGPS) on board the survey vessel. The onboard computer and black/white monitor were interfaced with the DGPS satellite positioning system. In addition to the onboard GPS receiver, a GPS station was set up at an established ACOE survey location, on the roof of the Army Corps of Engineers substation in Atlantic City, to provide differential corrections. Positioning data from the DGPS was converted by the onboard computer to New Jersey NAD 83 X,Y coordinates in real time. These X,Y coordinates were used to guide the survey vessel precisely along predetermined tracklines. While surveying, vessel positions were continually updated on the computer monitor to assist the vessel operator, and the processed X,Y data were continually logged on computer disk for post-survey processing and plotting.

Magnetic, acoustic and bathymetric data were collected simultaneously. Position coordinates, magnetic and bathymetric data were logged into the onboard computer. To allow for the detection of subtle magnetic anomalies typically associated with smaller wooden vessels, survey lane spacing for the survey was established at 75-foot offsets. Since the side scanning sonar transducer has an effective range of more than 150 feet in each channel, 75-foot lane offsets provided comprehensive acoustic coverage for each area. Bathymetric data was logged into the onboard computer continuously, and DGPS position fixes were recorded every 25 feet along each survey lane. Magnetic and acoustic records were event marked at regular intervals along each lane. This allowed researchers to rapidly integrate the acoustic, magnetic and bathymetric records into a survey map and to pinpoint the location of each identified target.

Magnetic data was contour plotted at 10 gamma intervals. Sonagram records were inspected for potential man-made features present on the bottom surface. After fieldwork data was collected, magnetic data was correlated with sonar and bathymetric records and targets of potential significance were identified and designated. Target signatures located during the survey were refined to permit highly accurate positioning and to facilitate signature analysis.

At Borrow Area 1, 35 survey lanes were completed in a northwest-southeast orientation, and 30 survey lanes were completed at Borrow Area 2 in an east-west orientation. Magnetometer data were contour plotted and each anomaly was analyzed in terms of the following parameters: magnetic intensity (total distortion of the magnetic background measured in gammas); pulse duration (detectable signature duration); signature characteristics (negative monopolar, positive monopolar, dipolar, or multi-component); and spatial extent (total area of disturbance). Acoustic (side scan sonar) targets were analyzed according to their spatial extent, configuration, location and environmental context. Magnetic records were correlated with the acoustic targets and integrated with bathymetric data to provide comprehensive remote sensing information on the identity of the material generating the remote sensing signatures. The integrated data for each target site were finally assessed with reference to typical submerged cultural resource signatures generated during three decades of magnetic and acoustic remote sensing surveys, enabling the isolation of target signatures that were suggestive of significant submerged cultural materials.

These procedures for analyzing remote sensing targets have been developed in the course of compiling a data base of target signatures over the last three decades. Starting in the 1960s, archaeologists primarily relied on magnetic remote sensing data, collected with proton precession magnetometers, to locate submerged cultural resources. However, magnetic data collected alone often provides inconclusive or partial evidence on submerged cultural resource sites. Underwater archaeological research conducted over the last two decades indicates that shipwreck sites may produce a variety of magnetic signatures. Furthermore, modern debris often generates magnetic signatures that may share similar characteristics with certain types of shipwreck sites.

The ambiguous nature of magnetic signatures has led researchers to use acoustic and occasionally sub-bottom remote sensing equipment in conjunction with a magnetometer on most underwater archaeological surveys. Acoustic data, in the form of sonagram records, are produced by processing sound waves emitted into the water column on both sides of the submerged sensor and bounced back off the bottom surface and exposed objects. State of the art sonar units can produce a high resolution sonagram record which is almost photographic in quality. However, a certain degree of structural integrity of a site must remain on or above the bottom to produce a reliable shipwreck signature on side scan sonar. Where no structure survives above the bottom surface researchers must rely on magnetic data to help locate shipwreck remains. Additional data provided by acoustic instruments frequently permits target identification to be made solely from remote sensing information. A combination of magnetic and acoustic remote sensing data has proven to be the most effective method to accurately identify and assess submerged archaeological sites. Typically, the most attractive targets produce both well-defined magnetic and acoustic signatures.

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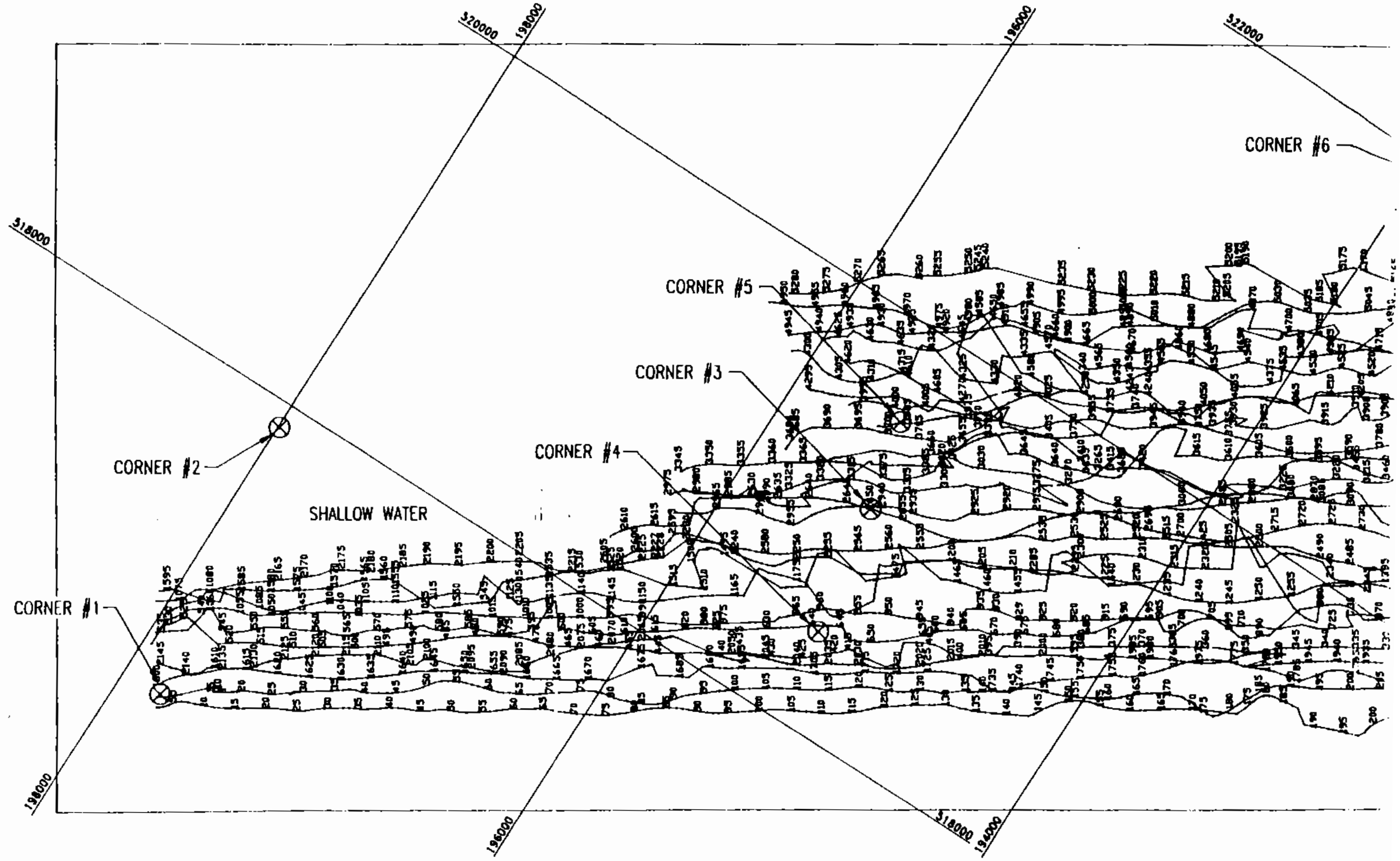
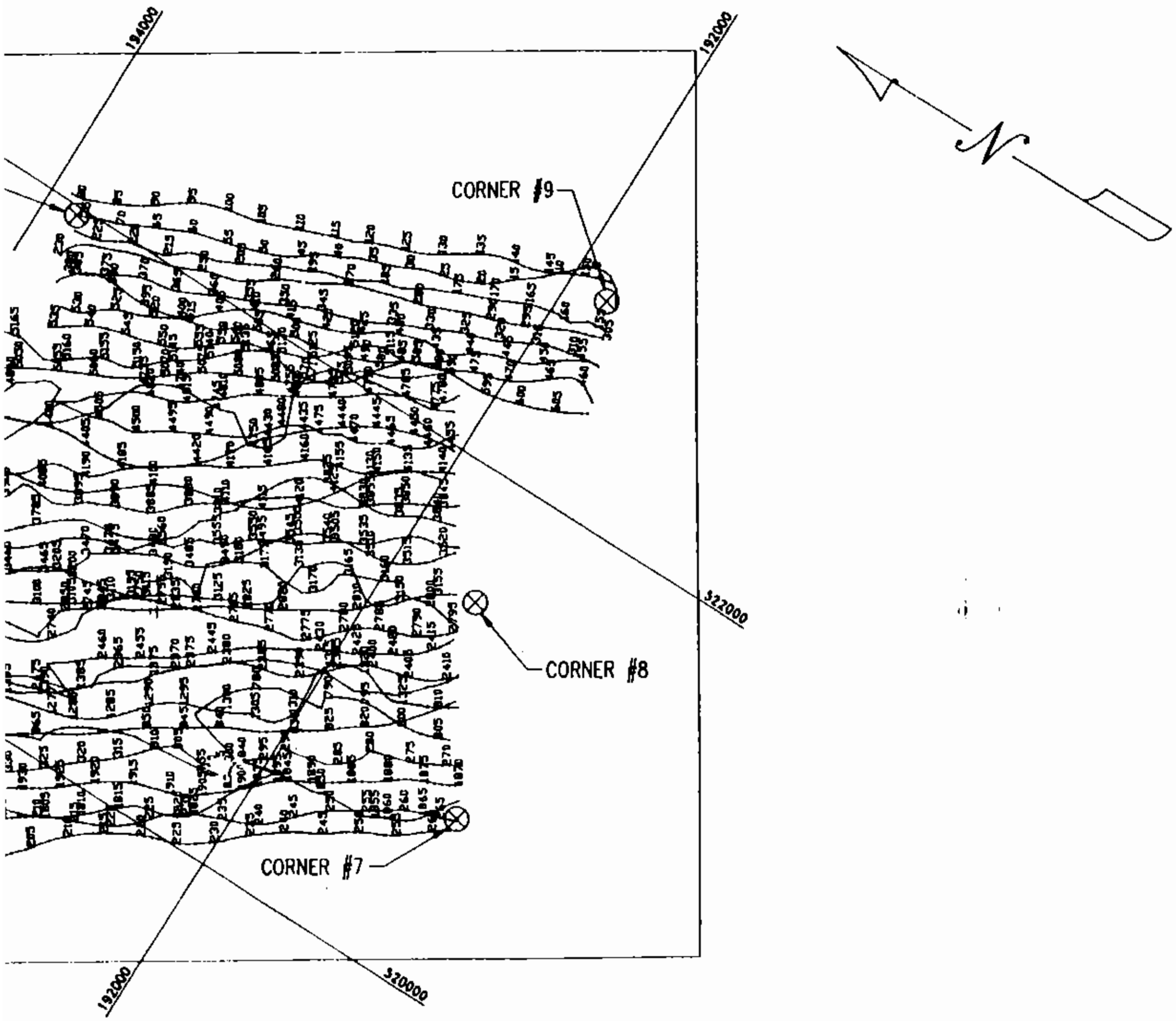


TRACK PLOTS

SCALE: 1"=500'

514



NOTES:

1. HORIZONTAL CONTROL F.:OVIDED BY U.S. ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT :EW JERSEY STATE TRAVERSE MECATOR PROJECTION – NAD 8: – ZONE 2900 INDICATED IN FEET
2. COORDINATES FOR SURV Y AREA CORNERS:

1. N 197793 E 516491	6. N 193849 E 521967
2. N 197993 E 517879	7. N 191217 E 520714
3. N 195363 E 519099	8. N 191623 E 521499
4. N 195262 E 518463	9. N 191827 E 522833
5. N 195465 E 519531	

3. SURVEY CONDUCTED ON 9/10/94 & 9/11/94

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•HISTORICAL RESEARCH
•MARINE SURVEY

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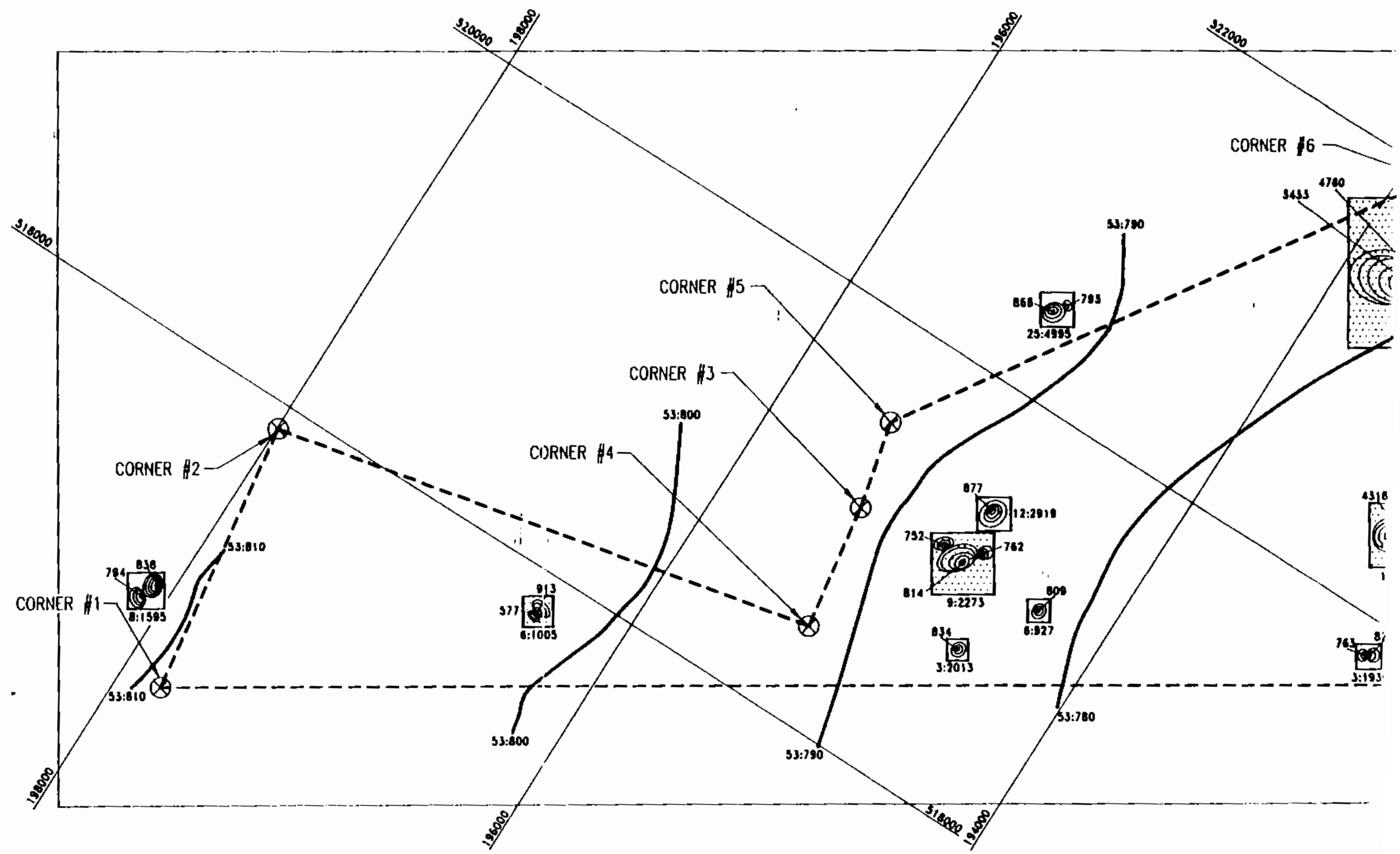
ABSECON BEACH REPLENISHMENT PROJECT
UNDERWATER ARCHAEOLOGICAL INVESTIGATION

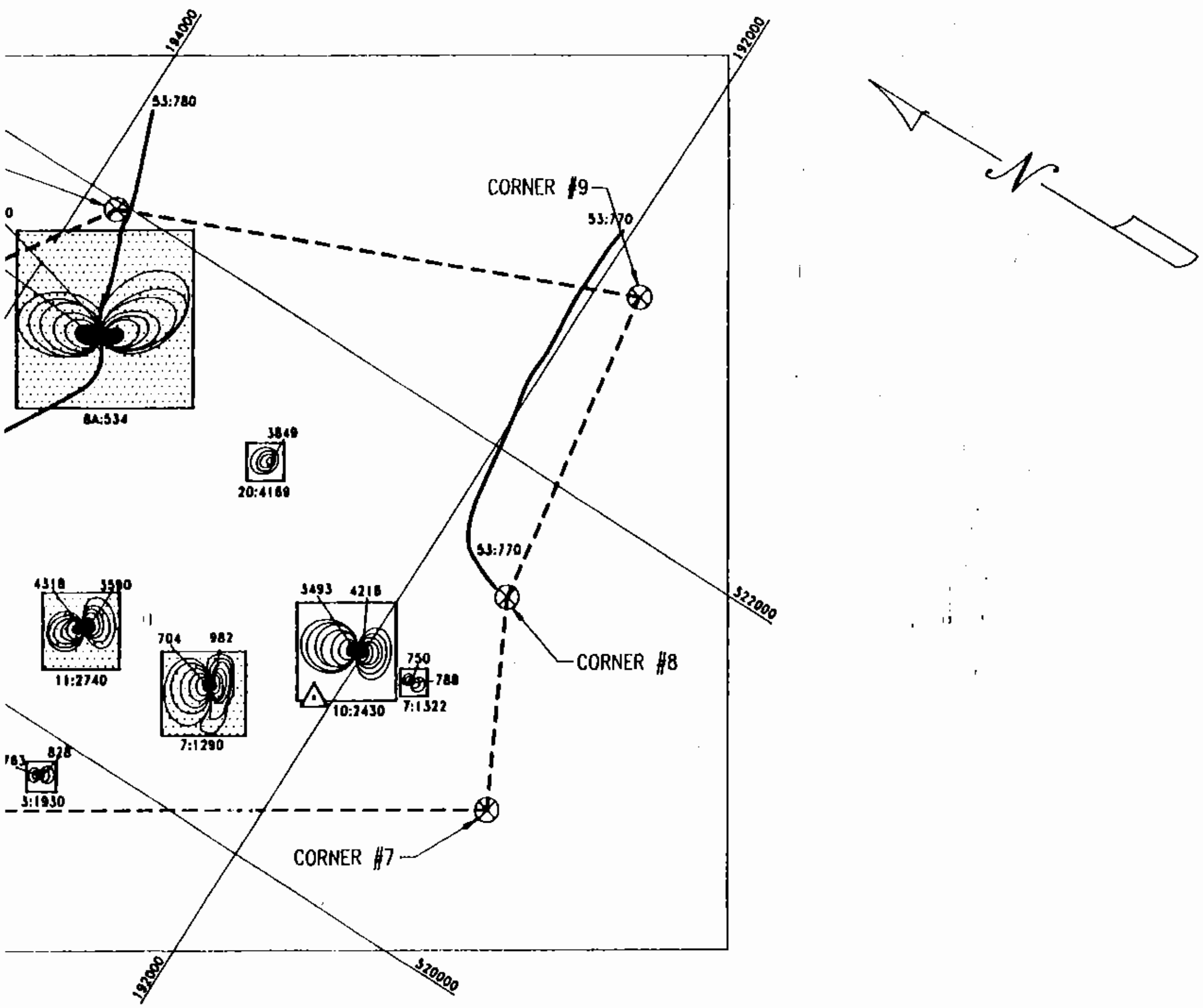
BORROW AREA 1

FIG. 6.



MAGNETIC CONTOUR AND TARGET MAP

SCALE: 1"=500'



NOTES:

1. HORIZONTAL CONTROL PROVIDED BY U.S. ARMY CORPS OF ENGINE! PHILADELPHIA DISTRICT NEW JERSEY STATE TRAVERSE MECATOR PROJECTION - NAD 83 - ZONE 2900 INDICATED IN FEET
2. MAGNETIC CONTOUR INTERVALS = 10 GAMMAS
3. MAGNETIC BACKROUND = 53:800
4. ⊡ MAGNETIC TARGETS
5. ⊡ HIGH PROBABILITY TARGETS
6. △ SONAR TARGETS
7. COORDINATES FOR SURVEY AREA CORNERS:

1. N 197793 E 516491	6. N 193849 E 521967
2. N 197993 E 517879	7. N 191217 E 520714
3. N 195363 E 519099	8. N 191623 E 521499
4. N 195262 E 518463	9. N 191827 E 522833
5. N 195465 E 519531	

8. SURVEY CONDUCTED ON: 9/10/94 & 9/11/94

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ABSECON BEACH REPLENISHMENT PROJE

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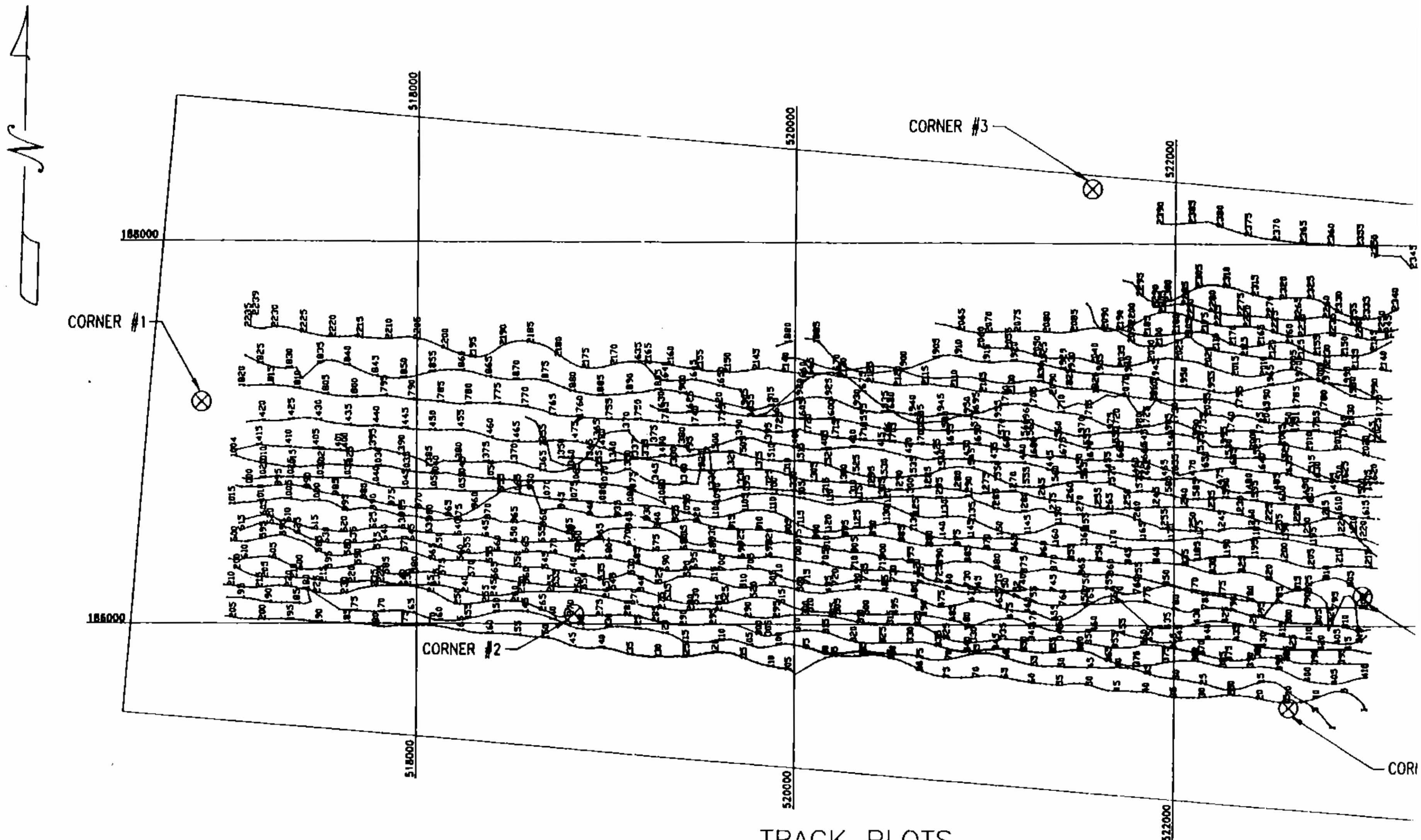
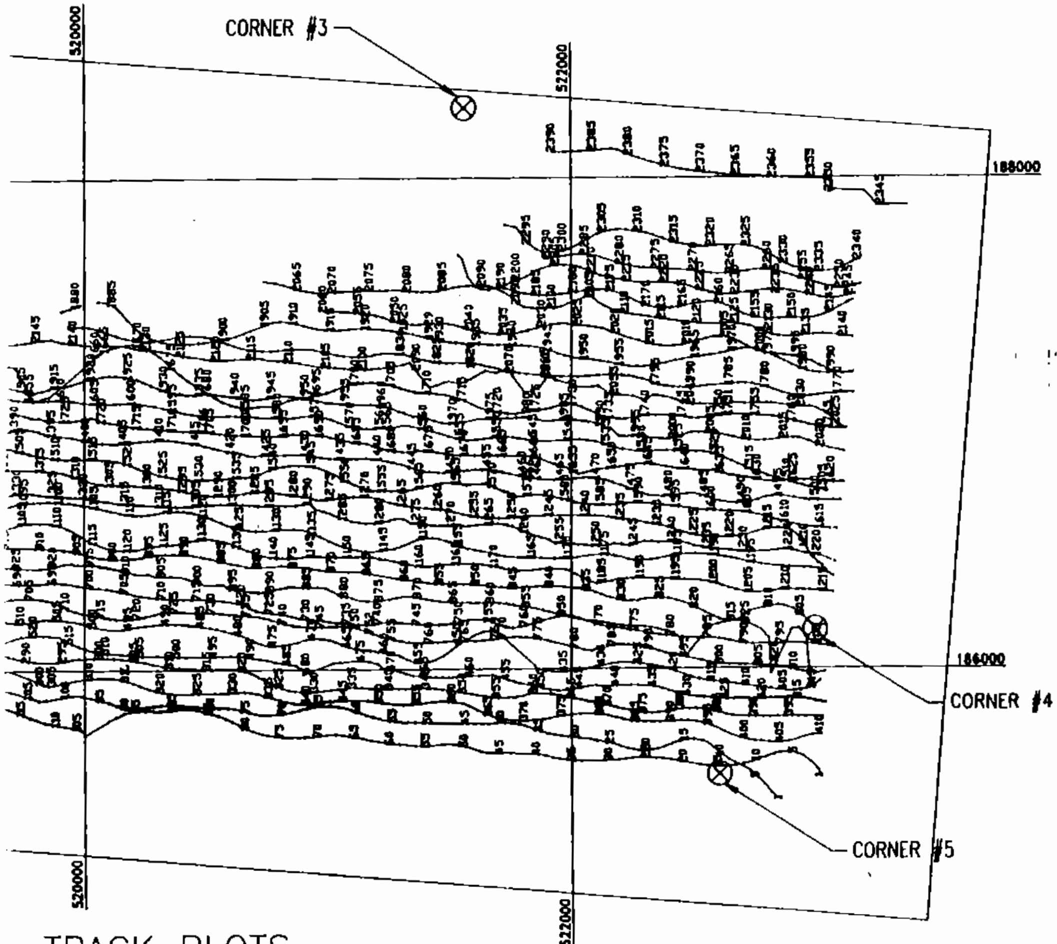
BORROW AREA 1



TRACK PLOTS

SCALE: 1"=500'



TRACK PLOTS

SCALE: 1"=500'

NOTES:

1. HORIZONTAL CONTROL PROVIDED BY U.S. ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT NEW JERSEY STATE TRAVERSE MECATOR PROJECTION – NAD 83 – ZONE 2900 INDICATED IN FEET
2. COORDINATES FOR SURVEY AREA CORNERS:
   1. N 187166.85 E 516869.65
   2. N 186055.96 E 518834.60
   3. N 188284.71 E 521561.45
   4. N 186161.82 E 522997.88
   5. N 185554.33 E 522605.83
3. SURVEY CONDUCTED ON: 9/9/94 & 9/11/94

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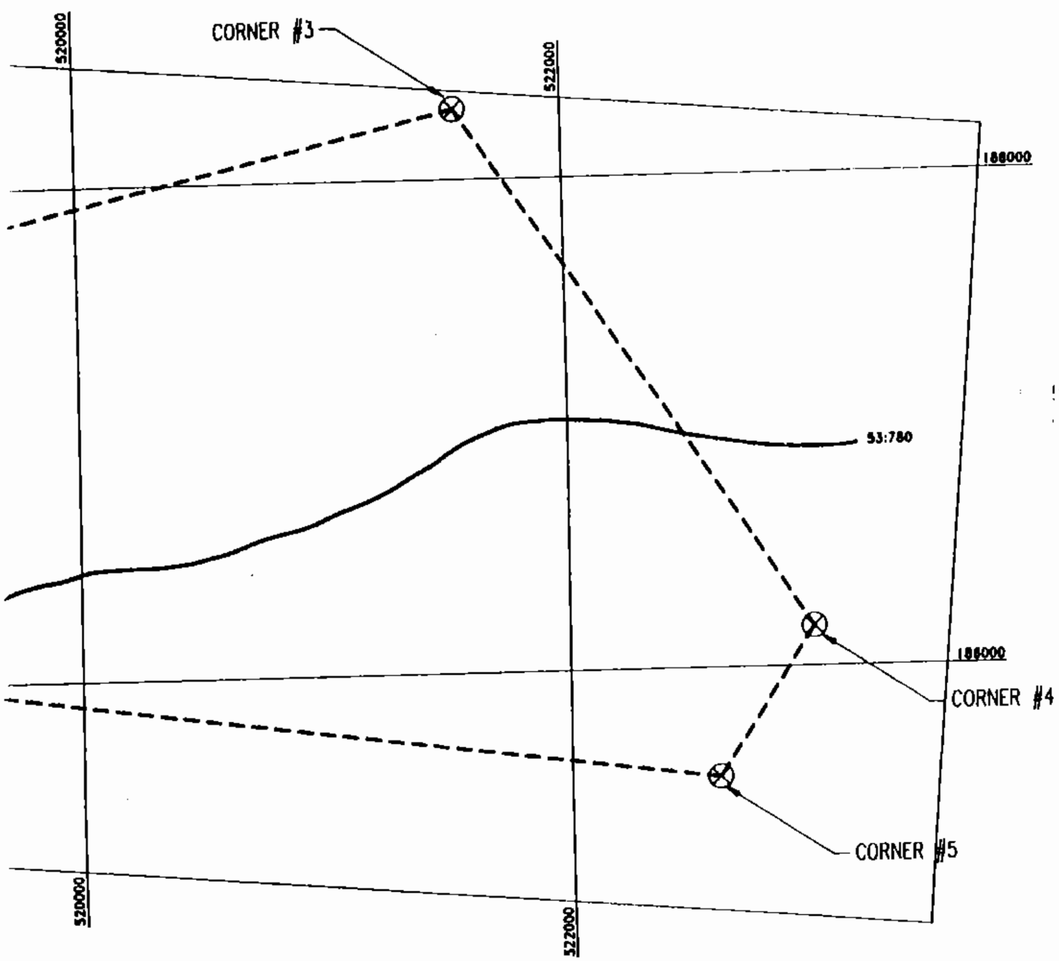
UNDERWATER ARCHAEOLOGICAL INVESTIGATION

BORROW AREA 2

FIG. No. 6.3

518



NOTES:

1. HORIZONTAL CONTROL PROVIDED BY U.S. ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT NEW JERSEY STATE TRAVERSE MECATOR PROJECTION – NAD 83 – ZONE 2900 INDICATED IN FEET
2. MAGNETIC CONTOUR INTERVALS = 10 GAMMAS
3. MAGNETIC BACKROUND = 53:780
4. COORDINATES FOR SURVEY AREA CORNERS:
   1. N 187166.85 E 516869.65
   2. N 186055.96 E 518834.60
   3. N 188284.7? E 521561.4?
   4. N 186161.8? E 522997.88
   5. N 185554.33 E 522605.83
5. SURVEY CONDUCTED ON: 9/9/94 & 9/11/94

NTOUF 'ID TARGET MAP

SCALE: 1"-

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BORROW AREA 2

FIG. No. 6.4

2. Findings of the Remote Sensing Survey:

Underwater survey was completed in the two proposed sand borrow areas in the Absecon Inlet vicinity by a four-person project crew from Dolan Research, Inc. between September 8-11, 1994. All underwater field survey notes, magnetometer and sonar records, are stored at the offices of Dolan Research, 4425 Osage Avenue, Philadelphia, PA 19014.

Borrow Area 1

Borrow Area 1 comprised a 270-acre area within which a total of 35 survey lanes were surveyed (Figure 6.1). Analysis of the remote sensing data confirmed the existence of 14 remote sensing targets in Borrow Area 1 (Figure 6.2). Of these targets, one is a combined magnetic-acoustic anomaly, while the other 13 are magnetic anomalies. Five of the magnetic anomalies (targets 6:1005, 7:1290, 9:2273, 11:2740 and 8A:534) generated remote sensing signatures that suggest the presence of submerged cultural resources. The other nine targets identified within Borrow Area 1 displayed signature characteristics typically generated by modern debris or by single, isolated objects buried beneath bottom sand.

Borrow Area 2

Borrow Area 2 comprised a 220-acre area within which a total of 30 survey lanes were surveyed (Figure 6.3). No magnetic or sonar anomalies suggestive of submerged cultural resources were identified (Figure 6.4).

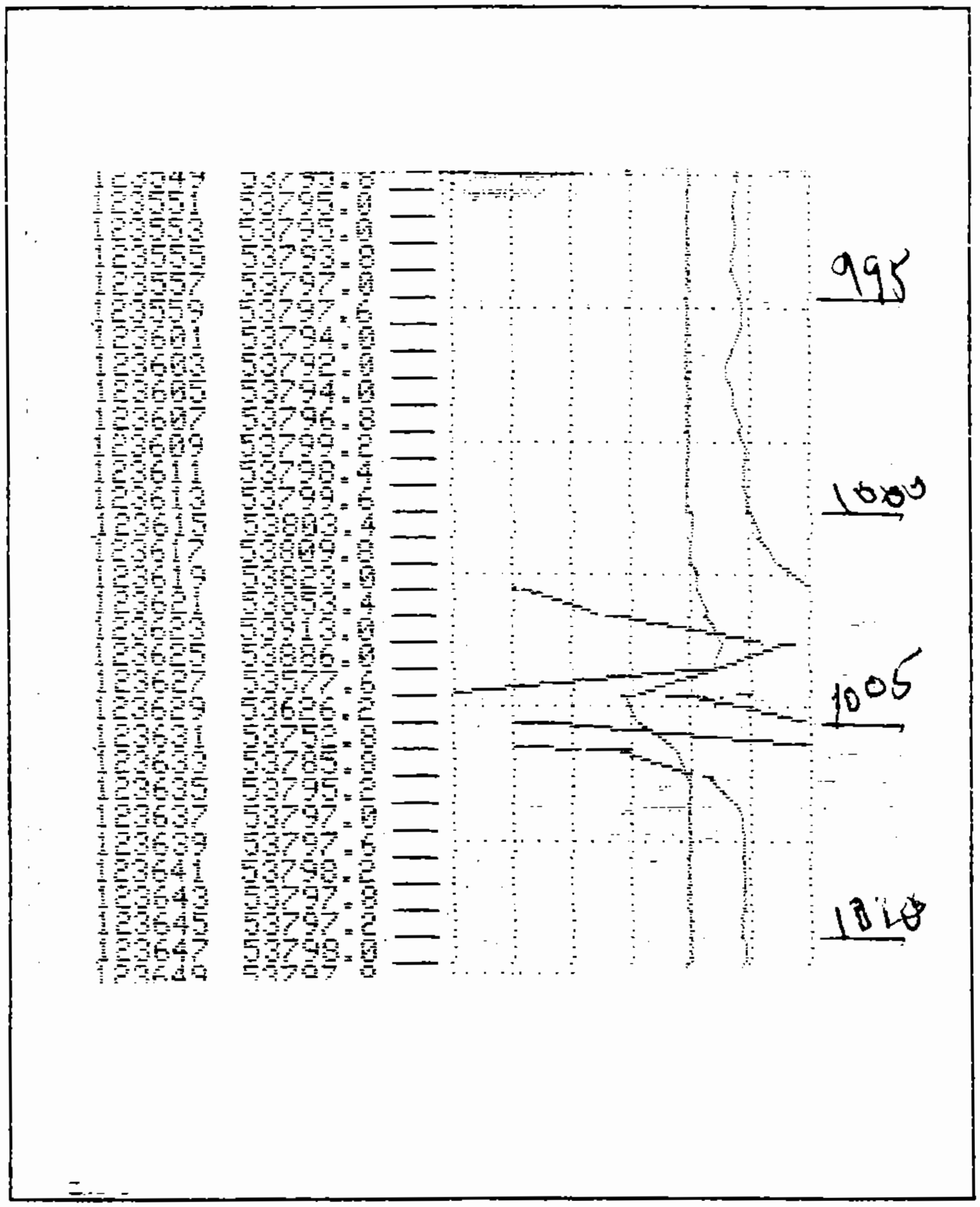
The remainder of this chapter is given over to a more detailed description of the observed anomalies located in Borrow Area 1. Target designations include the lane number(s) that the target was identified on, the target itself being identified by the lane number which came closest to intersecting the center point of the anomaly, followed by a colon and the event mark number along the specified lane. New Jersey State Plane Coordinates (NAD 83) are provided for each of the targets.

High Probability Targets

Target #: **6:1005**

Magnetic distortion generated by this broad anomaly was detected in lanes 5 and 6. The dipolar signature had a maximum distortion of 336 gammas that was detected over an 8 pulse duration - 16 seconds (Figure 6.5). Influence from the ferrous material at the site was identified across an area approximately 200 feet by 100 feet. Water depth across the target location was 22 feet.

520



ABSECON BEACH
BORROW AREA 1

MAGNETIC TARGET
6:1005

Figure 6.5

No associated acoustic target was identified at this location, suggesting that the material responsible for generating the magnetic signature is buried beneath the bottom sand. Plotting of the target location confirms that the center of the anomaly is near the western end of the survey area, inshore of the jetty at the southern tip of Brigantine Island, and on the north side of the navigational channel. The signature is suggestive of the presence of submerged cultural resources.

Coordinates: **N 517824**
E 196387

Target #: **7:1290**

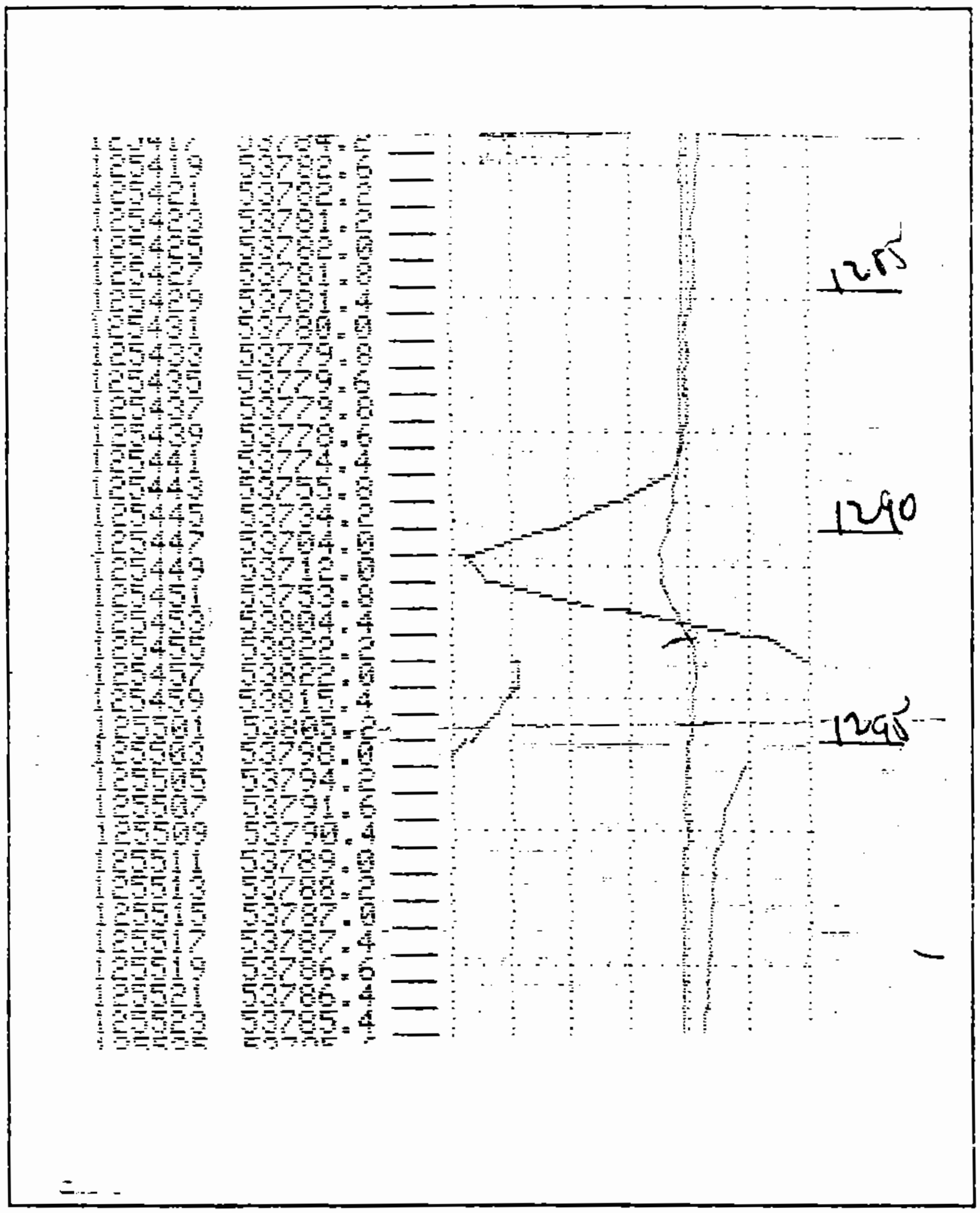
Magnetic distortion generated by this broad anomaly was detected in lanes 6, 7 and 8. The dipolar signature had a maximum distortion of 262 gammas that was detected over a 10 pulse duration - 20 seconds (Figure 6.6). Influence from the ferrous material at the site was identified across an area approximately 225 feet by 150 feet. Water depth across the target location was 20 feet. No associated acoustic target was identified at this location, suggesting that the material responsible for generating the magnetic signature is buried beneath the bottom sand. Plotting of the target location confirms that the center of the anomaly is close to southeastern corner of the survey area, offshore of the jetty at the southern tip of Brigantine Island, and on the north side of the navigational channel. The signature is suggestive of the presence of submerged cultural resources.

Coordinates: **N 520438**
E 192530

Target #: **9:2273**

Magnetic distortion generated by this broad anomaly was detected in lanes 7, 9 and 11. The dipolar signature had a maximum distortion of 115 gammas that was detected over a 14 pulse duration - 28 seconds (Figure 6.7). Influence from the ferrous material at the site was identified across an area approximately 240 feet by 100 feet. Water depth across the target location was 17 feet. No associated acoustic target was identified at this location, suggesting that the material responsible for generating the magnetic signature is buried beneath the bottom sand. Plotting of the target location confirms that the center of the anomaly is approximately 500 northeast of Target 7:1290, and is located close to the southeastern corner of the survey area, offshore of the jetty at the southern tip of Brigantine Island, and on the north side of the navigational channel. The signature is suggestive of the presence of submerged cultural resources.

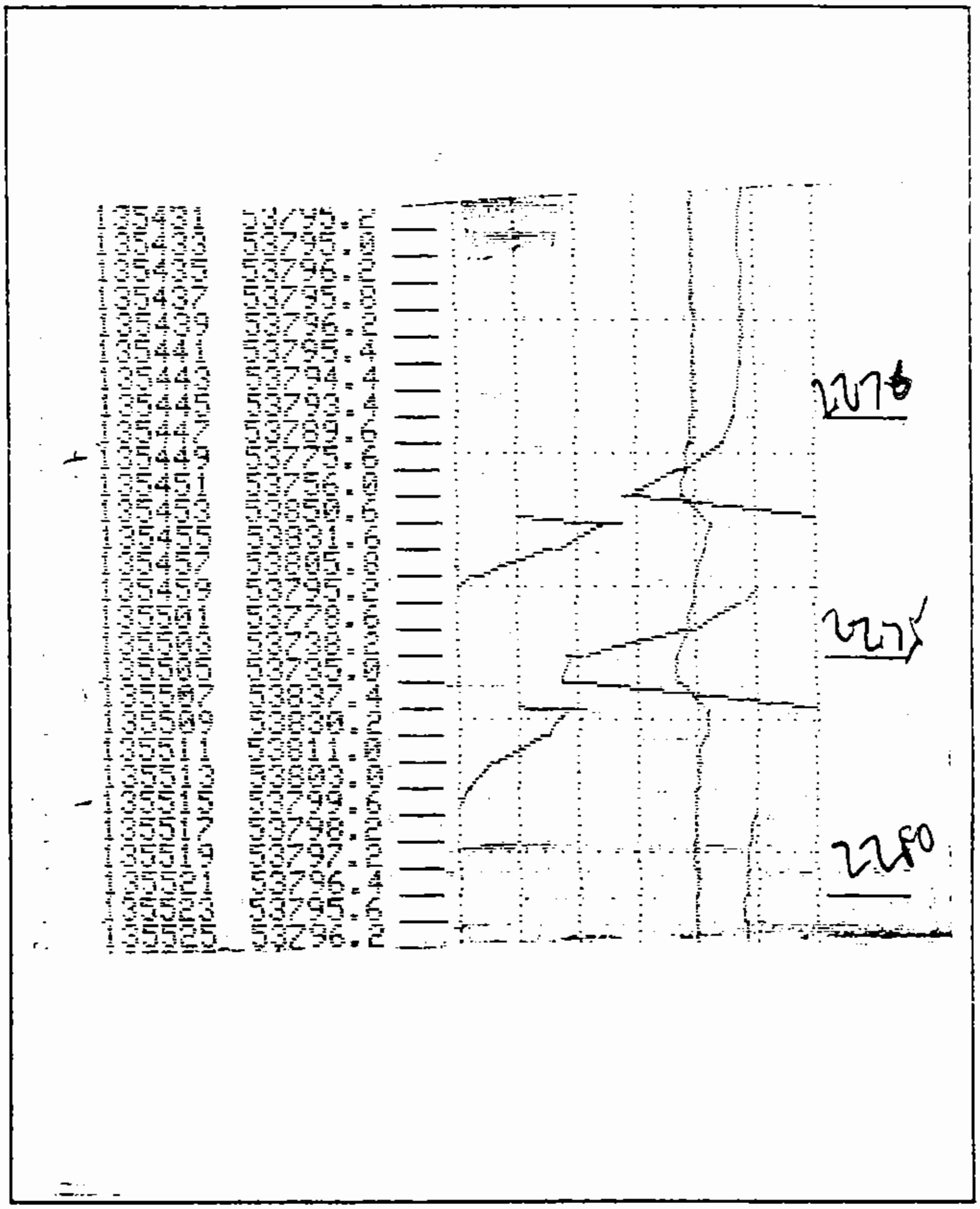
Coordinates: **N 520438**
E 192530



ABSECON BEACH
BORROW AREA 1

MAGNETIC TARGET
7:1290

Figure 6.6



ABSECON BEACH
BORROW AREA 1

MAGNETIC TARGET
9:2273

Figure 6.7

Target #: **11:2740**

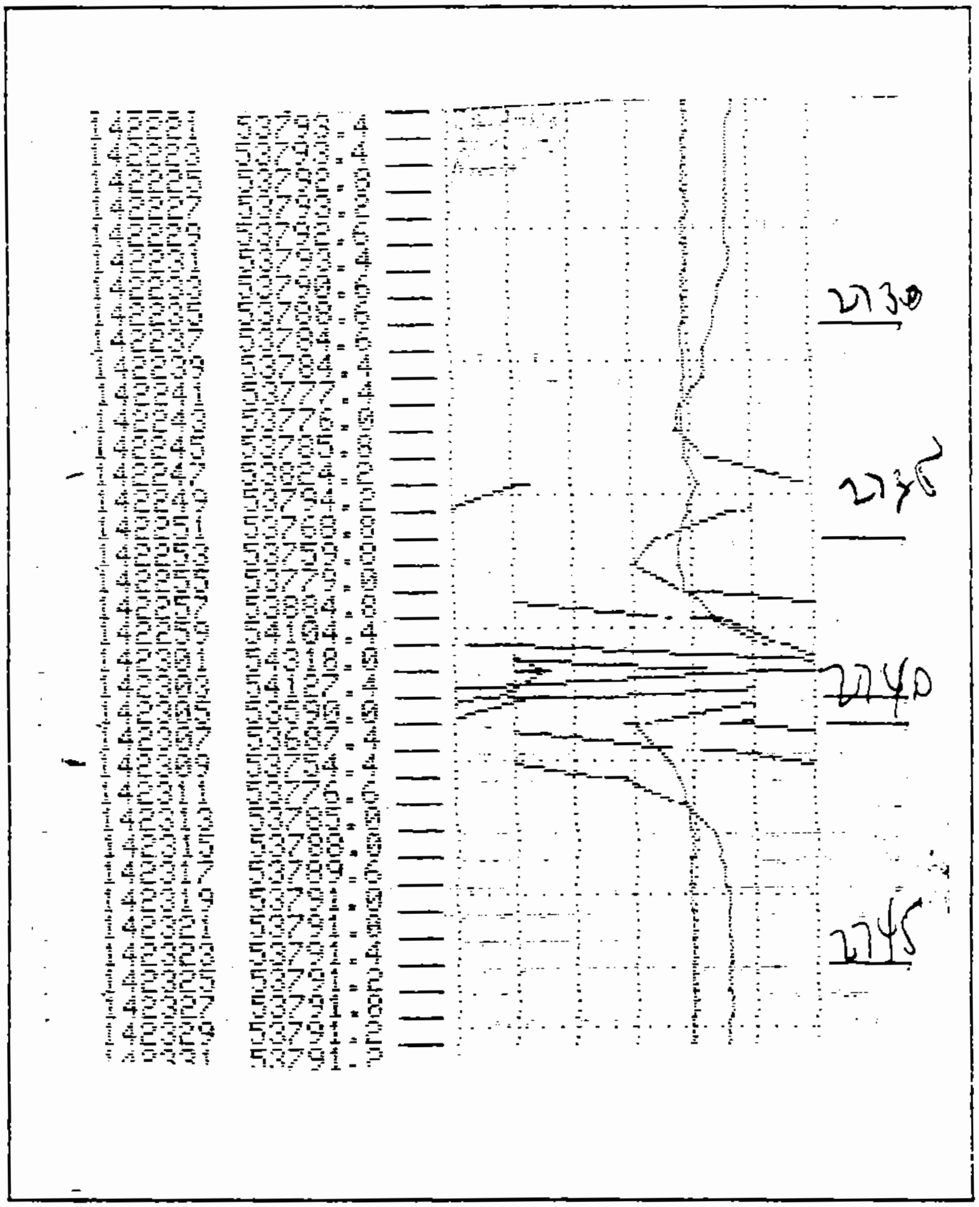
Magnetic distortion generated by this broad anomaly was detected in lanes 11 and 12. The dipolar signature had a maximum distortion of 723 gammas that was detected over an 11 pulse duration - 22 seconds (Figure 6.8). Influence from the ferrous material at the site was identified across an area approximately 220 feet by 75 feet. Water depth across the target location was 13 feet. No associated acoustic target was identified at this location, suggesting that the material responsible for generating the magnetic signature is buried beneath the bottom sand. Plotting of the target location confirms that the center of the anomaly is approximately 350 northwest of Target 7:1290, and is located near the center of the eastern portion of the survey area, offshore of the jetty at the southern tip of Brigantine Island, and on the north side of the navigational channel. The signature is suggestive of submerged cultural resources.

Coordinates: **N 520458**
E 193009

Target #: **8A:534**

Magnetic distortion generated by this broad anomaly was detected in lanes 26, 5a, 6a, 7a and 8a. The dipolar signature had a maximum distortion of 2,317 gammas that was detected over a 22 pulse duration - 44 seconds (Figure 6.9). Influence from the ferrous material at the site was identified across an area approximately 300 feet by 200 feet. Water depth across the target location was, on average, 15 feet. No associated acoustic target was identified at this location, suggesting that the material responsible for generating the magnetic signature is buried beneath the bottom sand. Plotting of the target location confirms that the center of the anomaly is in the northern portion of the eastern end of the survey area, offshore of the jetty on the southern tip of Brigantine Island, and well north of the navigational channel. The extensive magnetic signature is strongly suggestive of a large buried shipwreck.

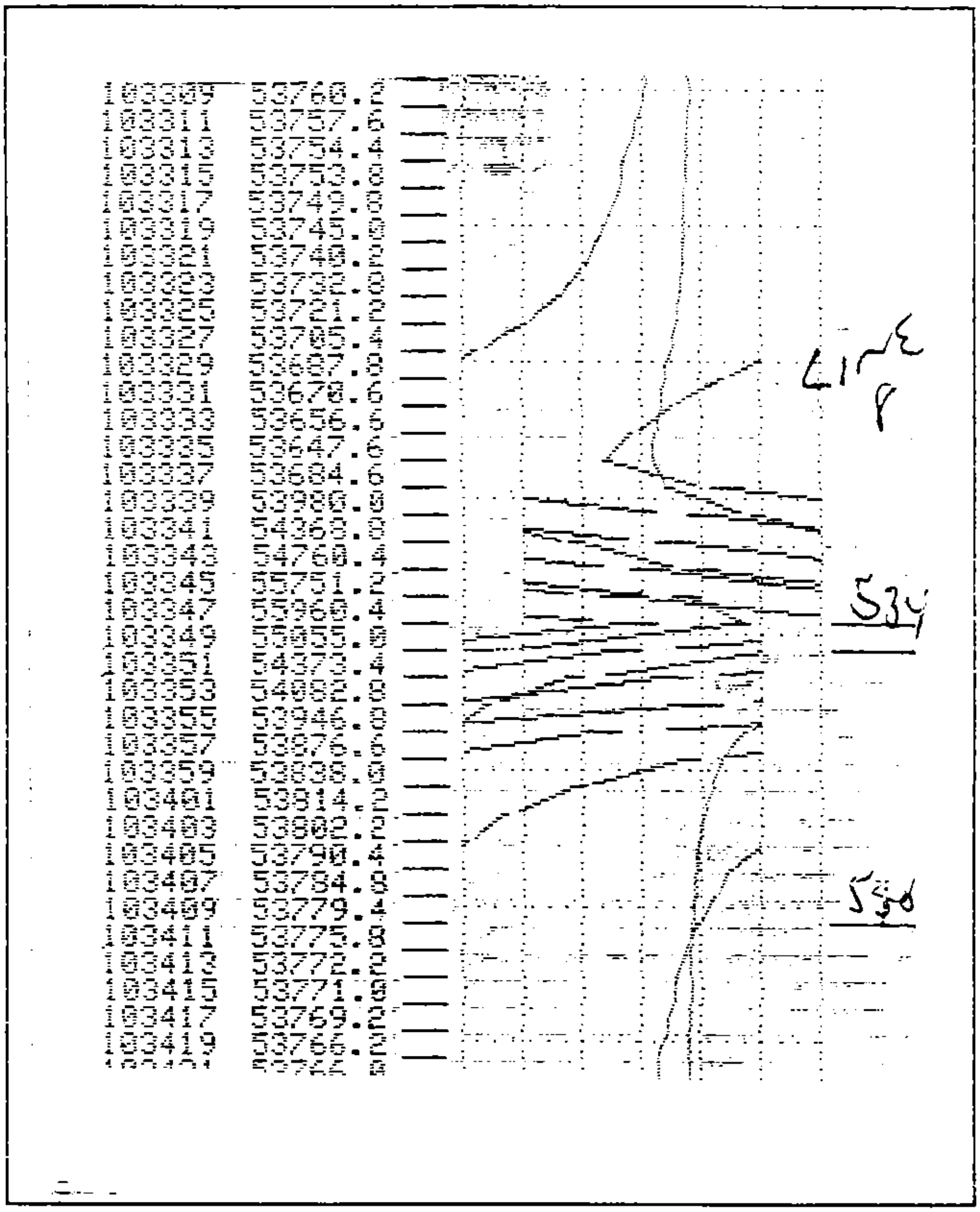
Coordinates: **N 521521**
E 193709



ABSECON BEACH
BORROW AREA 1

MAGNETIC TARGET
11:2740

Figure 6.8



ABSECON BEACH
BORROW AREA 1

MAGNETIC TARGET
8A:534

Figure 6.9

Other Magnetic Targets

Target #: **6:927**

Evidence of the magnetic signature of this target was only detected along lane 6. The positive, monopolar signature had a maximum distortion of 24 gammas that was detected over a 4 pulse duration. Water depth at the target location was 22 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 519080**
E 194407

Target #: **7:1322**

Evidence of the magnetic signature of this target was only detected along lane 7. The dipolar signature had a maximum distortion of 38 gammas that was detected over a 3 pulse duration. Water depth at the target location was 19 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 520983**
E 191698

Target #: **8:1595**

Evidence of the magnetic signature of this target was only detected along lane 8. The dipolar signature had a maximum distortion of 44 gammas that was detected over a 4 pulse duration. Water depth at the target location was 13 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 519080**
E 194407

523

Target #: **3:1930**

Evidence of the magnetic signature of this target was only detected along lane 3. The dipolar signature had a maximum distortion of 165 gammas that was detected over a 4 pulse duration. Water depth at the target location was 24 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 519876**
E 192781

Target #: **3:2013**

Evidence of the magnetic signature of this target was only detected along lane 3. The subtle positive, monopolar signature had a maximum distortion of 44 gammas that was detected over a 5 pulse duration. Water depth at the target location was 26 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 518745**
E 194588

Target #: **10:2430**

Evidence of the magnetic signature of this target was only detected along lanes 9, 10, and 11. The complex, dipolar signature had a maximum distortion of 723 gammas that was detected over an 11 pulse duration. Water depth at the target location was 17 feet. In addition to the main dipolar signature, there were two related anomalies on either side of the primary disturbance. An associated acoustic image was identified along lanes 9 and 10. Along lane 10, a section of cable was visible on the bottom surface, 15 feet out in the right channel. The complex nature of the magnetic signature indicates that the cable is likely associated with other features that are buried. Cable ~~or~~ wire rope of this size is typically modern in nature.

Coordinates: **N 521008**
E 192121

Target #: **12:2919**

Evidence of the magnetic signature of this target was only detected along lane 12. The positive. monopolar signature had a maximum distortion of 76 gammas that was detected over a 4 pulse duration. Water depth at the target location was 14 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 519474**
E 194774

Target #: **20:4169**

Evidence of the magnetic signature of this target was only detected along lane 20. The dipolar signature had a maximum distortion of 85 gammas that was detected over a 6 pulse duration. Water depth at the target location was 15 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 521455**
E 192731

Target #: **25:4995**

Evidence of the magnetic signature of this target was only detected along lane 25. The dipolar signature had a maximum distortion of 73 gammas that was detected over a 4 pulse duration. Water depth at the target location was 10 feet. There was no associated acoustic image at the target location, indicating that the material responsible for generating the magnetic signature is buried beneath the bottom surface. The lack of signature duration and dispersion indicates an isolated object.

Coordinates: **N 520403**
E 195084

CHAPTER 7

EVALUATION, IMPACT ASSESSMENT AND RECOMMENDATIONS

As with Chapter 5, this chapter maintains a distinction between inundated terrestrial resources (i.e., resources that were formed on land and have since been inundated by water or sediment as a result of rising sea level and other offshore depositional activity) and underwater resources (i.e., resources such as shipwrecks, downed airplanes or jetties, whose original formation occurred in a marine environment).

A. Submerged and Shoreline Terrestrial Resources

During the period of prehistoric and historic human activity in the Mid-Atlantic region, which extends over the past 15,000 years or so, the areas investigated during this study in the Absecon Island shoreline have experienced ongoing and increasing inundation as a result of rising sea level. For the most part, inundation has been accompanied by accumulation of sediments on the ocean floor, although offshore scouring and shifts in littoral drainage may also have produced local erosional effects. Cultural resources that were originally formed on land may now therefore lie submerged beneath the waters and variable depths of sediment in the Atlantic Shore Zone. Alternatively, they may also have been eroded through natural forces, such as water or wind action, or through human agency such as dredging.

It is extremely difficult to reconstruct in detail the natural environment (topography, drainage, soils, flora and fauna) and land use history of areas that are now submerged beneath the Atlantic Ocean and thereby derive an accurate assessment of prehistoric archaeological potential. The work of Kraft and others studying the geomorphology of the Delaware coastline is a valuable aid in understanding the processes that are at work and providing a hypothetical model for predicting cultural resource occurrence (see above, Chapter 3). However, testing such a model and reconstructing the geomorphology and geoarchaeology of any given section of inundated terrain within the Atlantic Shore Zone would require extensive and systematic bathymetrically-referenced sampling of the bay floor sediments, a task that is well beyond the scope of the current investigation. For this reason, it is not possible to offer a definitive evaluation of prehistoric archaeological potential for either the proposed sand borrow areas or the tidal zone on the basis of the research conducted to date.

At some future date, in the context of larger-scale engineering projects, a better sense of the paleoenvironment and prehistoric archaeological potential of the study area could perhaps be obtained from a carefully designed program of sediment sampling conducted jointly by coastal geomorphologists and archaeologists. Specifically, sampling of this type within the proposed sand borrow areas could establish the depth below the bay floor of prehistoric land surfaces and

Since the development of the shore resort community of Atlantic City, beginning in the mid-1850s, the Absecon Island shoreline has become progressively more built-up, to the extent that human land use has arrested slightly (and even reversed in some places) the steady post-glacial westward movement of the coastline. The construction of the Atlantic City boardwalk in the 1870s followed by the erection of a succession of piers and other shoreline structures have been an important part of this process. The historical significance of some of these features has been addressed in recent historic architectural studies in the city, and two of the piers -- the Steeplechase Pier (dating originally from 1899; rebuilt after a fire in 1932) and the Garden Pier (erected 1912-14) -- have been suggested as resources that are eligible for inclusion in the National Register of Historic Places (University of Pennsylvania et al. 1980). In the opinion of this consultant, the shoreline structures that underpin the eastern margin of Atlantic City are an integral part not only of this city's history, but also of the other shoreline communities to the southwest -- Ventnor, Margate and Longport. A reasonable case may be made that any such features which meet the National Register of Historic Places 50-year age criteria, and especially the major entertainment and fishing piers, are potentially of historical interest.

It is presumed that preservation of shoreline structures, even if they are presently ruinous, is entirely consistent with the goals of shoreline protection, since piers, groins and other features projecting into the ocean, perpendicular from the shore, can assist in stabilizing the strand. On this basis, and because resources that are potentially eligible for the National Register of Historic Places are involved, it is suggested that the beach nourishment actions take particular care not to disturb or destroy the various shoreline structures that project out from the Absecon Island shoreline. Indeed, if sand is placed sensitively around these structures, the project may be considered to have a beneficial effect, since it will slow their erosion by the sea and thereby enhance their preservation.

B. Underwater Resources

Background research confirms European maritime activity along the New Jersey Atlantic coast from at least as early as the first quarter of the 17th century. English, Dutch (and to a lesser extent Scandinavian) sailors were the first Europeans to explore the region during this period and were also the first to extensively traverse the waterways of the interior while establishing settlements in the present-day states of Pennsylvania, New Jersey and New York. Although extensive permanent settlement and development of Absecon Island did not occur until the mid-19th century, Absecon Inlet was used as a transportation artery by settlers inland as early as the 18th century. This local maritime activity was very limited in scope, however, and the vast majority of shipping activity within the offshore project areas was almost exclusively transient (i.e., coastal). Vessels crossing the project areas were participating in the network of coastal trade that linked the Delaware Bay ports and New York with other ports from Maine to Texas. International maritime traffic was also present in the project vicinity and involved shipping passing from the eastern seaboard to ports in the Caribbean and Central and South America. Much of this coastal traffic, when caught in heavy seas and bad weather between Sandy Hook to the north and Cape May to the south, deliberately sought shelter in Absecon Inlet.

As a result of the extensive historic maritime activity offshore of New Jersey's Atlantic coast, a wide variety of underwater resources may be anticipated in the Absecon Inlet vicinity. Indeed, more than 130 shipwreck losses and accidents have been documented along the New Jersey Atlantic coast near Absecon Inlet since the 18th century. The proposed dredging of the two offshore sand borrow areas may threaten any potentially significant submerged cultural resources that have been deposited in the immediate project vicinity.

A comprehensive remote sensing survey of Borrow Area 2 using magnetic, acoustic, and bathymetric instrumentation failed to identify any underwater resources. A similar survey procedure in Borrow Area 1, however, resulted in the identification of 14 magnetic targets, five of which exhibited remote sensing signatures characteristic of submerged cultural resources. The other nine targets identified within Borrow Area 1 displayed signatures typical of modem debris, or single, isolated objects buried beneath bottom sand. Only one of the identified targets produced an associated acoustic signature, confirming that the material responsible for generating the magnetic anomalies (with this one exception) is buried beneath bottom sediment. No additional archaeological investigation is recommended at these latter nine targets. Although no remote sensing was undertaken in the tidal zone, no visual evidence was observed of shipwrecks or other historic underwater resources. No further underwater investigation or remote sensing is considered necessary for the tidal zone.

The five targets identified in Borrow Area 1 as possessing remote sensing signatures characteristic of submerged cultural resources are all regarded as high probability targets. These targets are as follows: Target #: **6:1005**; Target #: **7:1290**; Target #: **9:2273**; Target #: **11:2740**; and Target #: **8:534**.

Consideration should be given to avoiding these target locations during sand borrow dredging activities. If avoidance is not a viable option, additional archaeological investigation (diving observation, overburden removal, and recording) is recommended at these targets to determine the nature of the object(s) responsible for generating the remote sensing signature. All of the targets are buried beneath bottom sediments. Ground truthing of these targets should also aim to preliminarily evaluate whether these potential underwater cultural resources are of sufficient caliber to merit inclusion in the National Register of Historic Places. As part of the resource identification and preliminary evaluation process, field data should also be correlated with background historical information. If a resource is considered potentially suitable for inclusion in the National Register, it should then become the focus of a more detailed Phase II archaeological investigation and the subject of National Register-level documentation.

C. Summary

In summary, the conclusions and recommendations from this submerged and shoreline cultural resources investigation are as follows:

1. The potential for significant submerged prehistoric terrestrial resources in the sand borrow areas is unclear, in large part because detailed reconstruction of the paleoenvironment is not possible at this level of study.

2. No further investigation of prehistoric terrestrial resources in the tidal zone or along the shoreline is considered necessary, since deposition of sand will enhance preservation of buried prehistoric resources (if indeed these exist).

3. Various structures (chiefly, entertainment and fishing piers and groins) have been identified along the Absecon Island shoreline dating from the late 19th century through to the mid- to late 20th century. The proposed beach nourishment should aid in the preservation of these shoreline structures (their being left intact should also help stabilize the shoreline), but care should be taken not to damage or remove these features during the placement of sand.

4. Apart from the protection of historic shoreline structures as defined in item 3 above, no further consideration of historic terrestrial resources in the sand borrow areas, in the tidal zone or along the shoreline is considered necessary. No documentary or field evidence has been found for such resources and they are considered extremely unlikely to exist.

5. Five magnetic underwater targets have been identified in Borrow Area 1 and may represent significant underwater resources such as historic shipwrecks. If these targets cannot be avoided, further investigation is recommended to clarify the character of these anomalies and to evaluate their eligibility for inclusion in the National Register of Historic Places.

4

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APPENDIX A

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

APPENDIX A

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

The following list of shipwrecks and marine accidents near Absecon Inlet and along Atlantic City's coast has been compiled from numerous primary and secondary sources. Among the sources used during the compilation of this list include: Maritime Records: Record of Wrecks 1874 - 1937 (Pennsylvania Historical Society); Encyclopedia of American Shipwrecks (Berman 1972); Shipwrecks off the New Jersey Coast (Krotee and Krotee 1965); Shipwrecks in the Americas (Marx 1971); Shipwrecks of New Jersey (Gentile 1988); Shipwrecks of Delaware and New Jersey (Gentile 1990); Annals of Brigatine (Burgess 1964): History of Atlantic City, New Jersey (English 1884); Surfboats, Rockets, and Carronades (Bennett n.d); Shipwrecks of New Jersey (North 1963); Daily Union History of Atlantic City and County, New Jersey, (Hall 1900); Automated Wreck and Obstruction Information System - AWOIS, (National Oceanographic and Atmospheric Administration); Merchant Vessels of the United States, Wreck List; The Monthly Nautical Magazine and Quarterly Review, The Steamship Inspection Service, Wreck File, 1852-1937; U.S. Coast Guard, Records of Life Saving Service; and Wreck Chart of the North American Coast of America (General Records of the Hydrographic Office, National Archives).

Many of the wrecks, particularly the more modern accidents that occurred in or near the inlet, were subsequently salvaged or removed because they were threats to safe navigation. Others almost certainly became quickly buried in the rapidly shifting sand patterns typical of high energy coastal.

Name	**Year Lost**	**Comments**
Ellis	ca. 1775	Ship from Liverpool and bound for New York, laden with tea and silver plate came ashore upon the shoals at Absecon beach.
Mermaid	1779	English transport ship from Whitehaven, was driven ashore at Little Egg Harbor at the north end of Brigantine Beach on March 31.
Roebuck	1780	British frigate of 44 guns was wrecked of the south end of Brigantine Beach.

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APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
George Cannon	1830	Ship from Liverpool, with a cargo of hardware and dry goods, came ashore at Absecon Beach and was a total loss.
Gherge's Khan	1830	Under the command of Captain Burk, the ship was totally destroyed off the Atlantic City beach.
John Willets	ca.1832	Barque became a total wreck upon the Atlantic City coast.
General Scot	1840	Schooner wrecked at Atlantic City.
Illinois	1844	Schooner from Philadelphia wrecked on the shoal at Absecon Inlet on November 27 and was a total loss.
Mohican	1845	Brig from New York wrecked on the south bar at Absecon Inlet on February 26 and was a total loss.
Rainbow	1845	Under the command of Captain Faircloyk, ship wrecked at Atlantic City.
Yazoo	1846	Schooner from Baltimore under the command of Captain Harrison struck on the bar at the southern end of Brigantine Island on March 27.
Osceola	1846	Brig from Plymouth wrecked on the south bar of Absecon Inlet on August 19.
Unidentifed schooner	1846	Schooner under the command of Captain Lowe wrecked on the beach at Atlantic City in October.
Margaret and Elizabeth	1847	Schooner of New York wrecked on Absecon bar off the southern end of Brigantine Island on January 7 and was a total loss.
Potapsco	1847	Brig of Boston was wrecked and stranded on Absecon bar at the southern end of Brigantine on September 28.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Florida	1847	Ship wrecked on Brigantine shoals.
Mississippi	1847	Schooner laden with corn peas, and beans took shelter in Absecon Inlet.
Laviant	1847	Brig from Boston, under the command of Captain Welch and carrying molasses, wrecked at Atlantic City.
Mary Ellen	1849	Barque from New York, ran ashore at Atlantic City in January.
Chester	1849	Barque from New Orleans, under the command of Captain Robinson, ran ashore at Atlantic City in March.
Walter A. Merchant	1849	Schooner from Washington, North Carolina, laden with naval stores and shingles, ran ashore at Atlantic City in November.
Brookhaven	1849	Schooner from Newport, came ashore on the south bar of Basecon Inlet on December 24.
Ayeshire	1849	Scottish barque wrecked on Brigantine shoals on December 29.
James A. Sanders	1850	Schooner from Hampton, Virginia, laden with oysters, came ashore at Atlantic City in May.
Four Brothers	1850	Brig from Philadelphia wrecked on the south bar of Absecon Inlet on May 6.
Canemain	1850	Brig from Boston, under the command of Captain Euptill and carrying coal wrecked at Atlantic City in December.
Reppler	1850	Barque bound for New York, laden with pepper wrecked at Atlantic City in December.

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APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Elviro Harber	1851	Barque from New York, laden with molasses and sugar wrecked at Atlantic City in January.
Wickwood	1851	Barque of Baltimore, laden with coffee, wrecked on Brigantine Beach in February.
Rio	1851	Schooner of Great Egg Harbor, laden with coal for New York wrecked at Brigantine Beach in February.
Elmira	1851	Schooner under the command of Captain Bulong wrecked on the south side of Absecon Inlet in September.
Patrick	1851	Sloop laden with clams, wrecked on the south side of Absecon Inlet in October.
Edward Prescott	1851	Brig from Boston wrecked on the south bar of Absecon Inlet on October 27.
Baldwin	1851	Brig from Southport with a cargo of cotton and merchandise wrecked on the south bar of Absecon Inlet on November 21.
Matogerde	1851	Barque of New York laden with lumber under the command of Captain Richardson, wrecked a Atlantic City in December.
Flying Dutchman	1851	Ship from Havana to New York with a general cargo came ashore on Brigantine Beach at about Twelfth Street North.
Hezeron	1852	Schooner from Newburyport wrecked on the south bar of Absecon Inlet on November 15.
Ellen Matilta	1852	Schooner from Calais wrecked on the bar at Absecon Inlet on December 23.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
William Lee	1852	Sloop grounded on Absecon bar on December 29 and was a total loss.
Rainbow	1852	Schooner of North Carolina carrying turpentine wrecked at Atlantic City in December.
John Willets	1853	Schooner from West Creek wrecked on the north bar of Absecon Inlet on February 19.
May Powell	1853	Schooner of New York laden with cotton and naval stores wrecked at Atlantic City.
Elizabeth	1853	Schooner of Mystic laden with cotton wrecked at Atlantic City in May.
Alving	1853	Schooner of Philadelphia and bound for New York carrying coal wrecked at Atlantic City in September.
James H. Braine	1853	Schooner of Yarmouth laden with logwood and mahogany wrecked on the south bar of Absecon Inlet on November 9.
Franklin	1853	Schooner carrying corn from Norfolk to New York wrecked at the south bar of Absecon Inlet on December 6.
Benjarnen Douglas	1853	Schooner under the command of Captain Taylor and laden with curbstone wrecked at the bar at Absecon Inlet on December 19.
Vesta	1854	Schooner laden with dry fish and bound for New York from Philadelphia came ashore on the south bar of Absecon Inlet on January 1.
S.T. Roberts	1854	Barque of Providence bound for New York from Marseilles wrecked at the south bar of Absecon Inlet on February 22.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Powhatan	1854	Packet ship went aground on Brigantine shoals and broke in two during a Northeast storm on April 15.
Manhatten	1854	Schooner struck upon Brigantine shoals about a half mile south of the Powhatan during the same storm on April 15.
H.S. Lanfair	1854	Schooner from Worwich wrecked on the north bar of Absecon Inlet on May 2.
Pedroga	1854	Brig from Nassau laden with logwood and sponge, came ashore on south side of Absecon bar and went to pieces in November.
New Era	1854	Ship carrying German immigrants wrecked off Brigantine on November 13.
Josephine	1855	Schooner laden with oysters wrecked near Atlantic City in January.
Thomas Y. Beckert	1855	Schooner from Wilmington, North Carolina, wrecked at Atlantic City in January.
May	1855	Schooner laden with oysters wrecked at Atlantic City in January.
Charles H. Mills	1855	Schooner carrying naval stores to New York wrecked at the south bar of Absecon Inlet on August 1.
Charles Colgate	1856	Schooner from New York ran aground on Brigantine Shoals on January 13 and was a total loss.
Truth	1856	Schooner from Norfolk wrecked on the south bar of Absecon Inlet on August 25..
Kirkland	1856	Barque from Baltimore to New York carrying coffee came ashore near Absecon Inlet.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Lyda Copathyle	1856	Schooner of Toms River carrying lumber came ashore below Dry Inlet in December.
M. Platt	1857	Schooner from New Bem laden with naval stores wrecked on the south bar of Absecon Inlet on January 27.
Corinelita	1857	Schooner under command of Captain Comell laden with hides and logwood wrecked near Atlantic City in January.
Jane Doughty	1858	Schooner from Absecon wrecked on the bar at Absecon Inlet on April 6.
Flying Dutchman	1858	Ship went to pieces at nearly the same spot where the Colgate broke.
Polly Whimple	ca. 1860	Wrecked at Atlantic City.
Maria	1863	Ship carrying cotton went ashore about a mile below the Excursion House.
Jewett	1864	Wooden steamer loaded with oranges came ashore on Brigantine Beach opposite the end of Tenth Street North.
Argene	1865	French barque came ashore on Brigantine Beach.
Armenia Bartlett	1865	Vessel came ashore on the beach at Atlantic City on December 27.
Cassandra	1867	Steamer, bound from New Orleans for New York struck Brigantine Shoals off North Tenth Street on February 5, and became a total loss.
Santiago de Cuba	1867	Ship came ashore at Atlantic City.

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APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Albert W. Fisk	1872	Schooner, 395 tons, was wrecked on Brigantine Beach on November 16.
Katie C. Rich	1874	Schooner, 425 tons, went aground on Brigantine shoals on March 29.
Rockaway	1877	An excursion steamer wrecked on the Atlantic City beach near Pennsylvania Avenue in March.
R.M. McCristol	1877	Yacht capsized on Absecon bar in November.
Twilight	1878	Schooner, 70 tons, ran ashore on Brigantine Beach in January.
Antonetta Costa	1879	Italian brigantine, 600 tons, wrecked on Brigantine shoals four miles north of Absecon Light in October.
Anson Stinson	1880	Schooner struck on beach at Atlantic City opposite West Jersey Excursion Home and was a total loss.
Lyda Reed	1880	Schooner from Cape May came ashore at Atlantic City and was a total loss.
Hatfield	1881	Barque, loaded with jute and flax, came ashore at Brigantine Inlet.
L.T. Whitmore	1881	Schooner, 295 tons, wrecked on Brigantine Shoals on April 13, and was a total loss.
W. D. Cargill	1881	Schooner, 141 tons, wrecked on Brigantine Shoals on April 13, and was a total loss.
Julia A. Reed	1881	Sloop went ashore at Atlantic City in October.
Wm. C. Wickham	1882	Schooner, 330 tons, struck on Brigantine shoals on January 2, and was a total loss.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Maggie Ellen	1882	Schooner. 217 tons. struck on Brigantine shoals on April 22. and was a total loss.
Abbie Campbell	1882	Schooner came ashore at Thirty-Fourth Street North. Brigantine Beach.
William Tell	1882	Codfish smack came ashore on Absecon bar. upper side of inlet on September 16 and was a total loss.
L. C. Wallace	1882	Sloop sank on the shoals at the entrance to Absecon Inlet on November 3.
Water Lily	1882	Sloop came ashore at Brigantine Beach at Thirty-Fourth Street, South.
Enterprise	1883	Schooner wrecked opposite Absecon Inlet on February 17 and went to pieces.
Clydesdale	1884	Steam sloop, 608 tons, wrecked on Absecon shoals on March 7, and was a total loss.
William Tice	1884	Schooner wrecked on the southerly end of Brigantine Beach May 17, and was a total loss.
Salisbury	1885	English steamer, 1,278 tons, wrecked on Absecon shoals February 1 1, and was a total loss.
Golden Light	1885	Sloop wrecked on the bar off the southerly end of Brigantine Island on March 13, and was a total loss.
Angie Predmore	1885	Schooner sank on the north shoals at Absecon Inlet on August 14.
Flash	1886	Sloop wrecked on the southerly end of Brigantine Beach on February 25, and was a total loss.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
Sylvan Glen	1886	Schooner wrecked on the north side of Absecon Inlet on July 3, and was a total loss.
Annie E. Fowler	1887	Schooner wrecked on the southerly end of Brigantine Beach on January 20, and was a total loss.
Unnamed yawl	1888	Yawl of the steamer Tonawanda wrecked on Brigantine Beach on January 1.
Samuel L. Russell	1888	Schooner, 194 tons, wrecked on the bar off the south end of Brigantine Beach on May 2, and was a total loss.
George Law	1889	Steamship went aground on the outer bar at the southerly end of Brigantine Beach on March 24, and was a total loss.
J.W. Luce	1889	Sloop wrecked on the south end of Brigantine Beach on April 2, 1889, and was a total loss.
Henry M. Clarke	1891	Schooner wrecked on the south side of Absecon Inlet on August 25, and was a total loss.
Venezuela	1892	Steamship, 2,843 tons, struck on Brigantine shoals on February 5, and was a total loss.
Enterprise	1893	Schooner bound for New York went to pieces near Absecon Inlet in February.
Bramble	1894	British ship, 1,508 tons wrecked on Brigantine shoals on June 25, and was a total loss.
Katie G. Robinson	1894	Schooner, 299 tons, wrecked on the south end of Brigantine shoal on July 10.
Sunbeam	1894	Schooner wrecked on Brigantine shoals on October 28.

APPENDIX A (Cont.)

ABSECON INLET, NEW JERSEY SHIPWRECK LIST

Name	Year Lost	Comments
William H. Davenport	1894	Schooner, 256 tons, wrecked on the outer bar off the southern end of Brigantine Beach on November 12.
Bea Bellido	1895	British schooner, 1,914 tons, went aground on Brigantine Beach on February 24.
Edith	1895	Schooner, 198 tons, wrecked on Brigantine Beach on February 24 and was a total loss.
Mary Ella	1895	Schooner wrecked on the north shoal of Absecon Inlet on May 11, and was a total loss.
Booth Brothers	1895	Schooner laden with lead bars and plate glass went down during a storm on the shoals off Fifteenth Street South in Brigantine.
Francis	1897	Sloop, 2,077 tons, bound from California for New York loaded with wine and salmon, burned two miles southeast of the Little Egg Harbor Life Saving Station.
Chocoma	1898	Schooner wrecked on Brigantine Beach on May 29, and was a total loss.
James Turpie	1899	British steamship, 1,732 tons, came ashore on Brigantine Beach on October 25.
Charles M. Kelley	1900	Steamship wrecked on Brigantine Beach on April 20.
A.T. Coleman	1901	Schooner came ashore opposite New Jersey Avenue, Atlantic City on January 20. Vessel floated off and became an obstruction in Absecon Inlet and was destroyed on June 4.
A.L. Lee	1902	Schooner wrecked on the bar near the mouth of Absecon Inlet on December 10.

APPENDIX B

STRUCTURES IDENTIFIED ALONG ABSECON BEACH, NEW JERSEY DURING LOW TIDE INSPECTION

APPENDIX B

STRUCTURES IDENTIFIED ALONG ABSECON BEACH, NEW JERSEY DURING LOW TIDE INSPECTION

The following is a list of structures identified during a pedestrian low-water survey along the eight-mile stretch of Absecon Beach. Structures are listed sequentially from south (Longport) to north (Atlantic City). Two archaeologists conducted the survey across the tidal zone at low tide on August 31 and September 13, 1994. All structures were oriented perpendicular to the surf line. Note - the following municipalities have been abbreviated as follows: Lpt=Longport; Mgt=Margate; Ven=Ventnor; and AC=Atlantic City.

No.	Location	Description
1	14th St. (Lpt)	Two parallel rows of timber heads with rock fill in between (storm drain pipe cover)
2	20th St. (Lpt)	Row of 12 timber heads (storm drain pipe cover)
3	23rd St. (Lpt)	Three timber heads (storm drain pipe cover)
4	27th St. (Lpt)	Two parallel rows of timber heads with rock fill in between, 7' x 100' (storm drain pipe cover)
5	29th St. (Lpt)	Two parallel rows of timber heads with rock fill in between, 7' x 100' (storm drain pipe cover)
6	Manor St. (Lpt)	Wood pilings with drain pipe visible
7	32nd St. (Lpt)	Two rows of timber heads with rock fill in between (storm drain pipe cover)
8	33rd St. (Lpt)	Timber frame with drain pipe above high water mark
9	Coolidge Ave. (Mgt)	Stone jetty/groin
10	Monroe Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, high water mark to low water mark
11	Jefferson Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, high water mark to low water mark

APPENDIX B (Cont.)

STRUCTURES IDENTIFIED ALONG ABSECON BEACH, NEW JERSEY DURING LOW TIDE INSPECTION

No.	Location	Description
12	Adams Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, high water mark to low water mark
13	Benson Ave. (Mgt)	Stone groin/jetty
14	Union Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides
15	Sumner Ave. (Mgt)	Bulkhead, sheathing with timber heads both sides, back with some rocks, high water to low water mark
16	Quincy Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, high water to low water mark
17	Osborne Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, 30' long from the middle of the tide zone to the low water mark
18	Mansfield Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, 15' long to low water mark,
19	Jerome Ave. (Mgt)	Stone groin extending into surf zone
20	Exeter Ave. (Mgt)	Margate Fishing pier extending into ocean beyond the surf zone
21	Brunswick Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, 15' long to low water mark
22	Argyle Ave. (Mgt)	Bulkhead/wooden groin, sheathing with timber heads on both sides, 35' long from low water mark into surf zone
23	Martindale Ave. (Ven)	Abandoned pier foundations at the south end of the Ventnor Boardwalk

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APPENDIX B (Cont.)

STRUCTURES IDENTIFIED ALONG ABSECON BEACH, NEW JERSEY DURING LOW TIDE INSPECTION

No.	Location	Description
24	Cambridge Ave. (Ven)	Ventnor City Fishing Pier
25	Dudley St. (Ven)	Timber heads from the remains of abandoned short pier that informants said formerly connected with the Ventnor Boardwalk

Five sets of timber heads for storm pipes were identified in Ventnor but their locations were not recorded.

No.	Location	Description
26	Morris Ave. (AC)	Two pilings and several timber heads extended out into the surf zone, which were marked with buoys; appears to be the remains of a former pier
27	Tropicana Casino (AC)	Outflow pipe
28	California Ave. (AC)	Outflow pipe
29	Convention Center (AC)	Outflow pipe at the south side of the center
30	Convention Center (AC)	Double outflow pipe at the north side of the center
31	Arkansas Ave. (AC)	Ocean One Mall Pier
32	Ocean One Mall Pier (AC)	Timber heads 25' north of the mall pier
33	Caesar's Casino (AC)	Outflow pipe, 30' north of the casino
34	Illinois Ave. Jetty (AC)	Outflow pipe, 15' south of the jetty
35	Illinois Ave. (AC)	Stone jetty/groin with timbers
36	Central Pier (AC)	Outflow pipe, 35' south of pier
37	Central Pier (AC)	Timber bulkhead groin, 15' south of pier
38	Tennessee Ave. (AC)	Central Pier

APPENDIX B (Cont.)

STRUCTURES IDENTIFIED ALONG ABSECON BEACH, NEW JERSEY DURING LOW TIDE INSPECTION

No.	Location	Description
39	Central Pier (AC)	Stone jetty/goin, 60' north of pier
40	Betw. Mansion & S. Carolina Aves. (AC)	Timber bulkhead groin
41	Steeplechase Pier (AC)	Outflow pipe, 20' south of pier
42	Resorts Casino (AC)	Steeplechase Pier
43	Steel Pier (AC)	Wooden bulkhead groin, 20' south of pier
44	Steel Pier (AC)	Steel Pier
45	Steel Pier (AC)	Outflow pipe, 50' north of pier
46	Showboat Casino south side (AC)	Outflow pipe with timber bulkhead from above high tide mark to 250' into surf zone
47	Showboat Casino north side (AC)	Old concrete pilings near high water mark
48	Oriental Pl. (AC)	Garden Pier
49	Connecticut Ave. (AC)	Outflow pipe with timber bulkhead which extends from the mid-tide mark 200' into the surf zone
50	Massachusetts Ave. (AC)	Stone jetty/groin
51	Victoria Ave. (AC)	Stone jetty/groin

APPENDIX C

RESUMES

J. Lee D. Cox Jr.

Curriculum vitae

Address
4425 Osage Avenue
Philadelphia, PA 19104

Date of Birth
June 24, 1959

OCCUPATION:	Maritime Archaeologist
EDUCATION:	East Carolina University, Greenville, N.C. Maritime History and Underwater Research M.A. Degree; May, 1985
	Duke University, Durham, N.C. Major; Anthropology/Archaeology B.A. Degree; May 1981
EXPERIENCE:	Career Related
June-July, 1994	Principal Investigator in the Phase I and II underwater archaeological project in the Delaware Bay and River. The multi-faceted investigation, which was associated with the Delaware Comprehensive Navigation Project, included remote sensing of four sand borrow areas, the ground truthing of eleven targets near the shipping channel, and the Phase II investigation of two wreck sites in the river. Work was completed for Hunter Research and the Army Corps of Engineers, Philadelphia District.
March, 1994	Principal Investigator in a Phase I underwater archaeological investigation in Vines Creek, near Dagsboro, Sussex County, Delaware. Work was completed for Hunter Research.
October, 1993	Principal Investigator in a Phase I underwater archaeological investigation completed in conjunction with the Fort Mott (N.J.) Pier Rehabilitation Project. Work was completed for Hudson Engineers.
October, 1993	Principal Investigator in a Phase I underwater archaeological remote sensing survey across Mantua Creek. Project was undertaken in conjunction with the proposed placement of a 30-inch force sewer main under the creek and adjacent tidal marsh. Work was completed for the Gloucester County Utilities Authority.
September, 1993	Principal Investigator in a Phase I underwater archaeological and bathymetric remote sensing survey at two proposed sand borrow areas in the Atlantic Ocean, offshore of Delaware's Atlantic Coast. Work was completed for the Army Corps of Engineers, Philadelphia District.
August, 1993	Archaeologist in a data recovery project on the shore of the Savannah River. Three vessels, including a center-board vessel, were excavated in conjunction with navigational improvement of the Savannah River. Work was completed for Mid-Atlantic Technology and the Army Corps of Engineers, Savannah District.
June-July, 1993	Principal Investigator in the Phase I and II underwater archaeological project in the Delaware Bay and River. The investigation, which was associated with the Delaware Comprehensive Navigation Project, focused on selected channel

	deepening areas, channel side slope portions, and turns between various channel ranges. Five previously identified targets were also investigated. Work was completed for The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.
April-May, 1993	Principal Investigator in a Phase I underwater archaeological survey in Great Egg Harbor Inlet, Ocean City, New Jersey. Work was completed for the Army Corps of Engineers, Philadelphia District, in conjunction with an on-going beach replenishment project.
March, 1993	Archaeologist in a Phase II underwater archaeological investigation of remote sensing targets at the mouth of the Cape Fear River, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
December, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Santee River, Georgetown County, South Carolina. Work was completed for Post, Buckley, Schuh, & Jernigan, and the South Carolina Department of Highways and Public Transportation.
November, 1992	Principal Investigator in a Phase I underwater archaeological survey in San Juan Harbor, San Juan, Puerto Rico. Work was completed for ArcheoMarine and the Army Corps of Engineers, Jacksonville District.
October, 1992	Archaeologist in a Phase I underwater archaeological survey in the Mississippi River, Prairie du Chein, Wisconsin. Work was completed for Tidewater Atlantic Research.
September, 1992	Archaeologist in a Phase I underwater archaeological survey in Aguadillo Harbor, Aguadillo, Puerto Rico. Work was completed for Mid- Atlantic Technology and the Army Corps of Engineers, Jacksonville District.
July, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Stono River, Charleston, South Carolina. Work was completed in conjunction with the proposed completion of the Mark Clark Expressway.
July, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River and Salem River, Gloucester County, New Jersey and New Castle County, Delaware. Work was completed for The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.
June, 1992	Archaeologist in the Data Recovery Project at a mid-nineteenth century sloop rigged sailing vessel in the North East Cape Fear River, Wilmington, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
May, 1992	Principal Investigator in a Phase I underwater archaeological survey in Rancocas Creek, Riverside, New Jersey. Work was completed for the Delran Sewerage Authority.
April, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River, Gloucester County, New Jersey and Delaware County, Pennsylvania. Work was completed for Hunter Research and Sun Oil Company.
March, 1992	Principal Investigator in a Phase I underwater archaeological survey in the Delaware River, Gloucester County, New Jersey and New Castle County, Delaware. Work was completed for Keystone Cogeneration Systems.

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January, 1992	Completed Statement of Historical Significance for the National Register Nomination Form of the U.S. Coast Guard Icebreaker Glacier. Work was completed for the U.S. Coast Guard.
December, 1991	Archaeologist in a Phase I remote sensing survey in Savannah River, Savannah, Georgia. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
December, 1991	Principal Investigator in Phase I underwater archaeological survey in Rancocas Creek, Riverside Park, New Jersey. Work was completed for the Delran Sewerage Authority.
November, 1991	Principal Investigator in Phase II Underwater Archaeological Investigation of three identified archaeological sites within the Burlington Coast Guard Station, Lake Champlain, Vermont. Work was completed for John Milner Associates and the United States Coast Guard.
October 1991	Archaeologist in a Phase I remote sensing survey at Brunswick, Georgia. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
September 1991	Archaeologist in Phase Ib underwater archaeological target investigation in Atlantic Ocean off Galilee, Rhode Island. Work was completed for Mr. Warren Reiss and AT&T.
September 1991	Archaeologist in Phase Ib target investigation in Atlantic Ocean adjacent to Beaufort Inlet, North Carolina. Initiated the documentation of a 19th century steamboat discovered in work area. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
August 1991	Completed background research and compiled content outline for Liberty State Park's traveling exhibit on the New York/New Jersey Harbor Estuary. Work was completed for Van Sickle & Rolleri.
August 1991	Archaeologist in the data recovery project at the wreck site of a 19th century tug/tow boat on the bank of the Savannah River. After complete excavation, the hull and all surviving steam machinery was comprehensively documented. Upon completion of data recovery, the steam engine, drive shaft and propeller were all raised and removed from the hull for conservation and eventual display in a local museum. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Savannah District.
July 1991	Archaeologist in the Phase I remote sensing and diving survey in Tobago Harbor in an effort to locate 17th century French and Dutch shipwreck sites. Work was completed for the Trinidad & Tobago National Museum.
June 1991	Archaeologist in a Phase II investigation of two shipwreck sites in Lake Superior. An ROV was used to map and record the remains of the two vessels which rest in waters below 100 feet deep. A National Register Nomination was completed for one of the wreck sites. Work was completed for Tidewater Atlantic Research.
June 1991	Principal Investigator in Phase Ib Underwater Archaeological Investigation for the State Route 58, Clarksville Bypass Project, Kerr Reservoir, Clarksville, Mecklenburg County, Virginia. Project was completed by Dolan Research, Inc. for Harland Bartholomew & Associates and the Virginia Department of

Transportation.

May 1991	Archaeologist in a Phase I remote sensing survey adjacent to Beaufort Inlet, North Carolina. Work was completed for Tidewater Atlantic Research and the Army Corps of Engineers, Wilmington District.
April 1991	Principal Investigator in Phase Ib Underwater Archaeological Investigation for the Woodrow Wilson Bridge Improvement Study. Project was completed by Dolan Research, Inc. for DeLeuw, Cather & Company of Virginia and the Virginia Department of Transportation.
February-March 1991	Archaeologist in the mitigation of a nineteenth century derelict vessel in the Savannah River, Savannah, Georgia. Work was completed for GAI and the Army Corps of Engineers, Savannah District.
January 1991	Conducted historical research for Phase I archaeological investigation at Naval Weapon Station, Earle, New Jersey, and Naval Weapon Station, Charleston, South Carolina, in conjunction with Homeporting Study for AOE-6 ships. Work was completed for Tidewater Atlantic Research, Inc., and Turner, Collie and Braden, Inc.
December 1990	Archaeologist in Phase I Underwater Archaeological Survey of Foundry Cove, Cold Spring, New York. Work was completed for Tidewater Atlantic Research, in conjunction with Grossman & Associates, and the Environmental Protection Agency.
October 1990	Archaeologist in Phase I Underwater Archaeological Survey of the Cape Fear River, below Wilmington, North Carolina. Work was completed for the Army Corps of Engineers, Wilmington District, by Tidewater Atlantic Research.
August 1990	Archaeologist in Phase I Underwater Archaeological Survey of three potential borrow areas off of Sarasota and Venice, Florida. Work was completed for the Army Corps of Engineers, Jacksonville District, by Tidewater Atlantic Research.
July/September 1990	Archaeologist in the Phase I & II Underwater Archaeological Investigation of the Sheboygan, Wisconsin, waterfront. Excavation and site documentation was completed on a mid-nineteenth century schooner, identified during initial remote sensing survey. Work was completed for the city of Sheboygan by Tidewater Atlantic Research.
May 1990	Principal Investigator in the Phase I Underwater Archaeological Investigation for the MD 213 Relocated, Alternate N-1B Bridge across the Chester River, Chestertown, Maryland. Project was completed by Dolan Research for John Milner Associates and the Maryland State Highway Administration.
April 1990	Completed background historical and archaeological research in conjunction with the construction of a bridge for the U.S. Route 58, Clarksville Bypass, Mecklenberg County, Virginia. Research was completed by Dolan Research for John Milner Associates.
April 1990	Principal Investigator in the Phase I Underwater Archaeological Investigation at the Salem Maritime National Historic Site, Salem, Massachusetts. Project was completed by Dolan Research for Louis Berger Associates and the National Park Service.
March 1990	Principal Investigator in the Phase II documentation of a mid-nineteenth century centerboard sailing vessel in the Cohansey River, Bridgeton, New Jersey. Project was completed by Dolan Research for Alan Mounier, Archaeologist.

Jan. - April 1990	Directed historical research and planning for the interpretive exhibit at Fort Mott, NJ. In addition to producing historical data for the exhibition, information was compiled for a fort brochure which included a self guided tour. Project was completed by Dolan Research for Van Sickle and Rolleri.
Nov. 1989 - Jan. 1990	Archaeologist in the Phase I and II underwater archaeological investigation at nine proposed range light locations in the Chesapeake Bay. Project was competed by Dolan Research, in conjunction with Ocean Surveys, Inc.
August - Dec. 1989	Completed background research and preliminary planning on the proposed exhibition at the Philadelphia Maritime Museum on the topic of early history and formation of the United States Navy in Philadelphia. Work was completed by Dolan Research for the Philadelphia Maritime Museum.
August 1989	Principal Investigator in the Phase I underwater archaeological investigation in Rock Creek, Anne Arundel County, Maryland. Three areas within the creek water system were surveyed for submerged cultural resources. Project was completed by Dolan Research for Dames and Moore.
July 1989	Archaeologist in the Phase I underwater archaeological investigation at the Charleston Navy Base, Cooper River, Charleston, South Carolina. Project was completed by Tidewater Atlantic Research for the United States Navy.
June 1989	Archaeologist in the Phase I and II underwater archaeological investigation at South Shore, Milwaukee, Wisconsin. Project was completed by Tidewater Atlantic Research for the Milwaukee Sewerage Authority.
April 1989	Archaeologist in the Phase 1 investigation at Brown Shoal, Delaware Bay. Project was completed by Ocean Surveys, Inc. for the Corps of Engineers, Philadelphia District.
March 1989	Field Director in the Phase II underwater archaeological investigation for the proposed Route 58 Midtown Tunnel, Portsmouth and Norfolk, Virginia. Project was completed by John Milner Associates for the Virginia Department of Transportation.
March 1989	Archaeologist in the Phase II and III investigation of two mid-nineteenth century shipwrecks in the Atlantic Ocean, offshore Longbranch, New Jersey. Project was completed by Tidewater Atlantic Research for Alpine Engineering and the Corps of Engineers, New York District.
November 1988	Archaeologist in a Phase II underwater archaeological investigation in the Gulf of Mexico near Ship Island, Mississippi. Project was completed by GAI Consultants for the Army Corps of Engineers, Mobile District.
September 1988	Field Director for the Phase II and III underwater archaeological investigation at the mouth of Crosswicks Creek, Bordentown, NJ. Project was completed by Louis Berger and Associates for the New Jersey Department of Transportation.
September 1988	Archaeologist for East Carolina University's graduate fieldschool in Bermuda. Work completed included assisting the Bermuda Maritime Museum's excavation of the 1620 NOS Shipwreck.
July - Sept. 1988	Completed background research and planning for proposed exhibition at the Philadelphia Maritime Museum on the history of underwater exploration and research.

July 1988	Archaeologist in the Phase II and III underwater archaeological investigation at a colonial rice plantation canal at Litchfield Beach, South Carolina. The project was completed by Tidewater Atlantic Research for Steve Coggans and Associates.
June 1988	Archaeologist in the Phase I and II terrestrial investigation for cultural resources adjacent to Chocowinity Bay, Chocowinity, North Carolina. Work was completed by Tidewater Atlantic research for the Weyerhauser Corporation.
April 1988	Archaeologist in the Phase I investigation of the Savannah River, Savannah, Georgia. Work was completed by Tidewater Atlantic Research for the Corps of Engineers, Savannah District.
Apr. 1987-Mar. 1988	Guest Curator at the Philadelphia Maritime Museum for the exhibition, "Ironclad Intruder: U.S.S. MONITOR." The exhibition focused on the historical significance, mythic role and archaeological investigation of the MONITOR. In addition to planning and organizing the entire exhibition, the curator also edited the exhibition catalogue.
December 1987	Archaeologist in the Phase II investigation for the Grace Memorial Bridge replacement project in the Cooper River, Charleston, South Carolina. Work was completed by Tidewater Atlantic Research for the South Carolina Division of Highways.
Sept.- Oct. 1987	Principle Investigator in the Phase I investigation in the Delaware River. The project was completed by the Maritime Historical Institute for Corps of Engineers, Philadelphia District's Delaware Comprehensive Navigation Project. Sixteen specific areas were studied in the Delaware, Salem and Maurice Rivers.
August 1987	Archaeologist in the Phase II and III investigation in Pensacola Harbor, Florida. Work, completed by Tidewater Atlantic Research in conjunction with the Navy Experimental Dive Unit, Panama City, Florida, documented and mapped thirteen remote sensing targets identified by the Army Corps of Engineers, Mobile District.
August 1987	Principal Investigator for the Phase I and II Archaeological Investigation in Slaughter Creek, Dorchester County, Maryland. Project was completed by John Milner Associates for the Maryland Department of Transportation in conjunction with a planned bridge replacement project.
July 1987	Archaeologist working in conjunction with the Hampton Roads Naval Museum and the United States Navy's Mobile Diving and Salvage Unit, Little Creek, Virginia to document the remains of the Civil War Sloop of War CUMBERLAND. Documentation of the site was achieved with the *SHARPS* system (Sonic High Accuracy Positioning System).
June 1987	Archaeologist in the excavation of the War of 1812 Brig JEFFERSON, in Sacketts Harbor, Lake Ontario, New York. The project was funded in part by the National Geographic Society.
March 1987	Archaeologist in the Phase I survey assessing the potential for submerged cultural resources in conjunction with the proposed construction of a tunnel under the Elizabeth River, between Portsmouth and Norfolk, Virginia. Work was completed by John Milner Associates for the Virginia Department of Transportation.

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August, Oct. 1986	Archaeologist in the Phase I investigation offshore of Ocean City, Maryland. The project was completed by Tidewater Atlantic Research for the Maryland Geologic Survey in conjunction with a proposed beach replenishment project.
July 1986	Principal Investigator in the Phase I, II and III investigation of Presque Isle Bay, Erie, Pennsylvania. The work, completed by the Maritime Historical Institute, was funded by a grant from the Pennsylvania Bureau for Historic Preservation, utilizing grant-in-aid funding from the Pennsylvania Division of Coastal Zone Management.
May - June 1986	Principal Investigator for the Phase III investigation of three shipwrecks in Pennsylvania waters. Two vessels in the Delaware River and one vessel in Misery Bay, Lake Erie, were documented. The work was funded by a grant from the Pennsylvania Bureau for Historic Preservation.
May - June 1986	Archaeologist in the Phase I underwater archaeological investigation in Long Island Sound, adjacent to New Rochelle, New York. Project was completed by Tidewater Atlantic Research for EBASCO.
April 1986	Principal Investigator for the Phase I investigation for submerged cultural resources in Delaware Bay. Work was completed for the Corps of Engineers, Philadelphia District.
March 1986	Principal Investigator for the Phase I and II investigation in Crosswicks Creek, Bordentown, New Jersey, in the vicinity of the right of way for a bridge span of I-295. In conjunction with a remote sensing survey in the creek, a site assessment of two eighteenth century wrecks was completed. The project was jointly funded by the Philadelphia Maritime Museum and the Pennsylvania Bureau for Historic Preservation.
December 1985	Archaeologist in the Phase I survey at Charleston, South Carolina. Work was completed by Tidewater Atlantic Research for the Corps of Engineers, Charleston District.
August 1985	Archaeologist in the Phase I and II underwater archaeological survey in the Potomac River at Alexandria, Virginia.
August 1985	Archaeologist in the Phase I and II survey in St. Michaels, Maryland, Harbor. The project was completed by Tidewater Atlantic Research for the Maryland Historic Trust.
July 1985	Principal Investigator for the Phase I and II investigation in Misery Bay, Lake Erie. The project was funded by the Pennsylvania Bureau for Historic Preservation and the Philadelphia Maritime Museum.
March 1985	Archaeologist in the Phase I survey offshore from Ocean City, New Jersey. The project was completed by Tidewater Atlantic Research for the Army Corps of Engineers, Philadelphia District.
December 1984	Archaeologist in the Phase I survey offshore from Kitts Hummock, Pickering Beach, Broadkill Beach and Bowers Beach, Delaware. Work was completed by Tidewater Atlantic Research for the Delaware Division of Soil and Water Conservation.
July 1984	Archaeologist representing the state of Pennsylvania during the Phase I and II underwater archaeological survey in Misery Bay, Lake Erie. The objective of the survey was to locate evidence of Oliver Perry's fleet from the War of 1812. The

	Pennsylvania Bureau for Historic Preservation sponsored this project which was conducted jointly by the Philadelphia Maritime Museum and the United States Naval Reserve Mobile Diving and Salvage Unit II, Little Creek, Virginia.
May 1984	Principal Investigator for the Phase I and II underwater archaeological survey in nine designated areas in the Delaware River. The work was funded by the Pennsylvania Bureau for Historic Preservation and the Philadelphia Maritime Museum and involved the participation of graduate students and personnel from East Carolina University.
June 1983	Archaeologist in the Phase I and II underwater archaeological investigation in Wenona Harbor, Maryland. The project was completed by Tidewater Atlantic Research for the Maryland Geologic Survey.
October 1982	Archaeologist in a Phase I and II underwater archaeological survey in the Chattahochie River at Columbus, Georgia. The investigation, completed by Tidewater Atlantic Research, was sponsored by the Confederate Naval Museum in an attempt to locate discarded ordnance from the Civil War.

GRANTS RECEIVED:

April 1986	Wrote proposal and directed for the Maritime Historical Institute, the Presque Isle Bay Underwater Archaeological Survey. Funding for the project was made available by the Pennsylvania Bureau for Historic Preservation utilizing grant-in-aid funding from the Pennsylvania Division of Coastal Zone Management. A magnetometer and side scan sonar survey with diving investigations was completed in Presque Isle Bay, Lake Erie.
July 1985	Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to document and assess three shipwrecks in Pennsylvania waters to determine the archaeological and historical significance of each.
July 1984	Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to assess the potential presence of submerged cultural resources in the Monongahela, Ohio and Allegheny Rivers and the Lake Erie Shoreline.
July 1983	Wrote proposal and directed for the Philadelphia Maritime Museum a grant from the Pennsylvania Bureau for Historic Preservation which was designed to assess the potential presence of submerged cultural resources in the Delaware and Susquehanna Rivers.

REPORTS:

February, 1994	Submerged Cultural Resources Investigation Delaware Atlantic Coast From Cape Henlopen To Fenwick Island. Submitted to the Army Corps of Engineers, Philadelphia District.
January, 1994	Submerged Cultural Resources Investigations, Delaware River Main Channel Deepening Project, Delaware, New Jersey, and Pennsylvania. Submitted to The Greeley-Polhemus Group and the Army Corps of Engineers, Philadelphia District.
November, 1993	Phase IA & IB Underwater and Terrestrial Archaeological Survey; Gloucester County Utilities Authority, Mantua Creek Force Main, Gloucester County.

	Submitted to Gloucester County Utilities Authority.
June, 1993	Submerged Cultural Resources Investigation, Great Egg Harbor Inlet & Peck Beach, Ocean City, New Jersey. Submitted to the Army Corps of Engineers, Philadelphia District.
May, 1993	Underwater Archaeological Reconnaissance: Route US 17A/SC 41, Santee River Bridge Replacement, Berkeley and Georgetown Counties, South Carolina. Submitted to Post, Buckley, Schuh & Jernigan.
October, 1992	Aquatic Cultural Resources Investigation, Salem Cove - Delaware River, Salem County, New Jersey and New Castle County, Delaware. Submitted to the Army Corps of Engineers, Philadelphia District.
June, 1992	Phase I Underwater Archaeological Remote Sensing Survey; Riverside Sewerage Authority STP Upgrade, Burlington County, New Jersey. Submitted to Richard Alaimo Associates.
April, 1992	Submerged Cultural Resource Survey; Keystone Cogeneration Plant, Delaware River, New Castle County, Delaware & Gloucester County, New Jersey. Submitted to Keystone Cogenerations Systems and the Delaware Division of Historical and Cultural Affairs.
April, 1992	Submerged Cultural Resource Survey; Keystone Cogeneration Plant, Delaware River, Gloucester County, New Jersey. Submitted to Keystone Cogenerations Systems and the Office of the New Jersey Heritage.
March, 1992	A Phase II Archaeological Evaluation of Identified Archaeological Resources at the USCG Station Burlington, Burlington, Vermont. Submitted to United States Coast Guard.
February, 1992	Statement of Historical Significance for the USCG Icebreaker Glacier. Statement was submitted to the United States Coast Guard in conjunction with the development of a nomination form for the National Register of Historic Places.
January, 1992	Phase I Underwater Archaeological Remote Sensing Survey; Delran Sewerage Authority Pipeline Extension, Burlington County, New Jersey. Submitted to Richard Alaimo Associates.
September 1991	Phase Ib Underwater Archaeological Survey for the U.S. Route 58, Clarksville Bypass Study, Clarksville, Mecklenburg and Halifax Counties, Virginia. Submitted to Harland Bartholomew and Associates, Inc.
June 1991	Phase Ib Underwater Archaeological Survey for the Woodrow Wilson Bridge Improvement Study. Submitted to DeLeuw, Cather & Company of Virginia.
December 1990	Phase 1a Cultural Resources Investigation for the U.S. Route 58 Corridor Study (Clarksville Bypass), Mecklenburg County, Virginia. Co-authored with Cheek, Stevens, Seifert and Meyer. Submitted by John Milner Associates to the Virg.nia Department of Transportation.
July 1990	MD 213 Relocated, Alternate N-1B Phase I Underwater Archaeological Reconnaissance Chester River, Chester River, Chestertown, Maryland. Submitted by Dolan Research and John Milner Associates to the Maryland State Highway Administration

May 1990	Underwater Archaeological Remote Sensing Reconnaissance, Salem Maritime National Historic Site, Salem, Massachusetts. Submitted by Dolan Research to Louis Berger Associates and the National Park Service.
April 1990	Archaeological Investigation: Cohansey River Wreck Site, Bridgeton, New Jersey. Submitted by Dolan Research to Alan Mounier, Archaeologist.
March 1990	Fort Mott Historical Narrative. Submitted by Dolan Research to Van Sickle and Rolleri.
January 1990	Archaeological Discussion of Magnetic and Acoustic Remote Sensing Data for the Chesapeake Range Lights Project, Maryland and Virginia. Submitted by Dolan Research to Ocean Surveys, Inc.
September 1989	Underwater Archaeological Investigation of Rock Creek, Anne Arundel County, Maryland. Submitted by Dolan Research to Dames and Moore.
June 1989	Phase II Archaeological Investigations for the Proposed Route 58 Midtown Tunnel Portsmouth and Norfolk, Virginia. Co-authored with Stevens and Heck. Submitted by John Milner Associates to the Virginia Department of Transportation.
February 1989	A Report on the Phase I and Phase II Archaeological Investigation for Revolutionary War Vessels Within the Alignment of I-295 (The Trenton Complex) Crosswicks Creek, Bordentown, New Jersey. Co-authored with Fokken. Submitted by Louis Berger & Associates to the New Jersey Department of Transportation.
July 1988	Submerged Cultural Resources Investigations, Delaware River, Main Navigational Channel, Philadelphia, PA. to Artificial Island, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
May 1988	Submerged Cultural Resources Investigations, Maurice River, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
April 1988	Submerged Cultural Resources Investigations, Salem Cove and River, New Jersey. Submitted to the Corps of Engineers, Philadelphia District.
January 1988	A Phase I Cultural Resources Survey for the Proposed Route 58 Midtown Tunnel Portsmouth and Norfolk, Virginia. Co-authored with Checks, Stevens, Meyer and Glendening. Submitted by John Milner Associates to the Virginia Department of Transportation.
December 1987	Underwater Archeological Survey and Evaluation for the Route 16 Bridge Replacement over Slaughter Creek, Dorchester County, Maryland. Co-authored with Struthers and Parrington. Submitted by John Milner Associates to the Maryland State Highway Administration.
December 1986	Presque Isle Bay Underwater Archaeology Survey. Submitted to the Pennsylvania Historical and Museum Commission.
November 1986	A Historical and Archaeological Assessment of Three Submerged Cultural Resources in Pennsylvania. Submitted to the Pennsylvania Historical and Museum Commission.
July 1986	A Marine Cultural Resources Reconnaissance and On Site Evaluation of Crosswicks Creek, Bordentown, New Jersey. Co-authored with Watts.

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	Submitted to the Philadelphia Maritime Museum.
April 1986	A Sensitivity Level Investigation of Cultural Resources in the Vicinity of; the Main Navigational Channel, Delaware River, Wilmington to the Sea and a Proposed Deepwater Port. Submitted to the Corps of Engineers, Philadelphia District.
October 1985	A Preliminary Survey to Analyze the Potential Presence of Submerged Cultural Resources in the Ohio, Monongahela and Allegheny Rivers and the Pennsylvania Portion of Lake Erie. Submitted to the Pennsylvania Bureau for Historic Preservation.
September 1984	A Preliminary Survey to Analyze the Potential Presence of Submerged Cultural Resources in the Delaware and Susquehanna Rivers. Submitted to the Pennsylvania Bureau for Historic Preservation.
July 1983	A Reconnaissance of the Chattahochie River at Columbus, Georgia. Co-authored with Watts, Still and Hall. Submitted to the Confederate Naval Museum at Columbus, Georgia.
June 1983	The Yorktown Shipwreck Project; Fall Work Season 1982. Co-authored with Newell. Submitted to the Virginia Branch for Underwater Archaeology, Gloucester Point, Virginia.
March 1983	Submerged Survey for Sir Walter Raleigh's Lost Colony: Roanoke Island, North Carolina. Submitted to the North Carolina Underwater Archaeology Branch, Fort Fisher, North Carolina.

PUBLICATIONS:

1990	*USS Shipwreck: Underwater Archaeology and U.S. Navy Divers.* In, Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference. Tuscon.
1988	Ironclad Intruder: U.S.S. MONITOR: A collection of essays on the history, symbolism and archaeological importance of the U.S.S. MONITOR. Co-edited with M. Jehle. Philadelphia Maritime Museum. Philadelphia.
1988	*Shipwrecks.* In, The Delaware Estuary: Rediscovering a Forgotten Resource. Edited by T. Bryan and J. Pennock. University of Delaware Sea Grant Program, Newark.
1987	*Preliminary Investigation of a Revolutionary War Era Vessel in Crosswicks Creek, Bordentown, New Jersey.* In, Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference. Savannah.

LECTURES:

Episcopal Academy Family Forum Lecture Series, 1994
Philadelphia Maritime Museum Friends of the Library Lecture Series, 1993
The 21st Annual Conference on Underwater Archaeology, Tuscon, AZ., 1990
The 43rd National Preservation Conference, National Trust for Historic Preservation, Philadelphia, 1989
New Jersey State Museum Lecture Series, 1988
Pennsylvania Historical and Museum Commission, 4th Annual Archaeology Workshop, 1988

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

RICHARD W. HUNTER
President/Principal Archaeologist, MA, SOPA

Education

Ph.D. Candidate, Geography, Rutgers University, New Brunswick, New Jersey, 1984-present

M.A., Archaeological Science, University of Bradford, England, 1975

B.A., Archaeology and Geography, University of Birmingham, England, 1973

Experience

1986- Principal Archaeologist, Hunter Research, Inc.
Cultural Resource Consultants, Trenton, NJ

Founder and principal stockholder of firm providing archaeological and historical research, survey, excavation, evaluation, and report preparation services in the Northeastern United States. Specific expertise in historical and industrial archaeology (mills, iron and steel manufacture, pottery manufacture), historical geography, historic landscape analysis.

Participation in:
- Project management, budgeting and scheduling
- Proposal preparation and client negotiation
- Hiring and supervision of personnel
- Supervision of research, fieldwork, analysis and report preparation

1983-1986 Vice-President/Archaeologist, Heritage Studies, Inc., Princeton, NJ

Principal in charge of archaeological projects.
Responsibilities included:
- Survey, excavation, analysis, and reports
- Client solicitation, negotiation, and liaison
- Project planning, budgeting, and scheduling
- Recruitment and supervision of personnel

1981-1983 Principal Archaeologist, Cultural Resource Group, Louis Berger & Associates, Inc., East Orange, NJ

Directed historical and industrial archaeological work on major cultural resource surveys and mitigation projects in the Mid-Atlantic region. Primary responsibility for report preparation and editing.

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1979-1981	Archaeological Consultant, Hopewell, NJ
1978-1981	Adjunct Assistant Professor, Department of Classics and Archaeology, Douglass College, Rutgers University, NJ
1978-1979	Research Editor, Arete Publishing Company, Princeton, NJ Prepared and edited archaeological, anthropological, and geographical encyclopedia entries (Academic American Encyclopedia, 1980).
1974-1977	Archaeological Field Officer, Northampton Development Corporation, Northampton, England Supervised archaeological salvage projects executed prior to development of the medieval town of Northampton (pop. 230,000). Experience included: • Monitoring of construction activity • Supervision of large scale urban excavations • Processing of stratigraphic data and artifacts • Preparation of publication materials
1969-1970	Research Assistant, Department of Planning and Transportation, Greater London Council

Special Skills and Interests

- historic landscape analysis
- geographic information systems
- water-powered mill sites
- iron and steel manufacture before the Industrial Revolution
- scientific methods in archaeology

Publications

Hopewell: A Historical Geography. Township of Hopewell. Richard L. Porter, co-author. 1991.

"Contracting Archaeology? Cultural Resource Management in New Jersey, U.S.A" (with Ian Burrow). The Field Archaeologist (Journal of the Institute of Field Archaeologists) 12, March 1990, 194-200.

"American Steel in the Colonial Period: Trenton's Role in a 'Neglected' Industry." In Canal History and Technology Proceedings IX, 83-118, 1990. Richard L. Porter, co-author.

"The Demise of Traditional Pottery Manufacture on Sourland Mountain, New Jersey, during the Industrial Revolution." Ch. 13 in Domestic Potters of the Northeastern United States, 1625-1850. Studies in Historical Archaeology, Academic Press, 1985.

"Scientific Aids in Pottery Fabric Analysis." In Medieval Pottery, Processing and Publication. Department of the Environment, U.K. Government, 1983.

Excavations at St. Peter's Street, Northampton, 1973-74. Northampton Development Corp., 1979. John Williams, senior author.

"Excavations at Thorplands, Northampton, 1970 and 1974." Northamptonshire Archaeology 12, 97-154, 1977.

Professional Affiliations

Society of Professional Archaeologists (accredited 1979; certification in field research, collections research, theoretical or archival research)
New Jersey State Historic Sites Review Board (Member, 1983-present)
Professional Archaeologists of New York City (PANYC)
Society for Historical Archaeology
Society for Industrial Archaeology
Society for Post-Medieval Archaeology
Council for Northeast Historical Archaeology
Archaeological Society of New Jersey

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

BROOKE S. BLADES
Principal Archaeologist, M.A.

Education

Ph. D. Candidate, Anthropology, New York University, New York, NY, 1988-present

M.A., American Civilization, University of Pennsylvania, Philadelphia, 1978

B.A., History, College of William and Mary, 1973

Experience

1994-present — Principal Investigator, Hunter Research, Inc., Trenton, N.J.

Technical and managerial responsibilities for selected research, field, laboratory and report preparation components of archaeoological projects. Participation in:
- research, survey, excavation, analysis and reports
- project supervision and on-site management
- management of laboratory operations and graphics production
- supervision of field, laboratory and drafting personnel
- preparation of proposals
- personnel recruitment

1991-1993, 1974-1988 — Archaeologist, Mid-Atlantic Regional Office, National Park Service, Philadelphia, PA

Responsibilities included:
- preparation of research designs
- preparation of requests for proposals
- consultant selection
- contract administration
- all aspects of project review, including research, fieldwork, analysis, and report

Also designed, executed and directed archaeological and historical research programs at numerous federally-owned managed historic sites, including:
- Fort McHenry National Monument, Baltimore, Maryland
- Valley Forge National Historical Park, Philadelphia, Pennsylvania
- Independence National Historical Park, Philadelphia, Pennsylvania
- Delaware Water Gap National Recreation Area, Pennsylvania
- George Washington Birthplace National Monument, Montross, Virginia
- Fredericksburg and Spotsylvania National Military Park, Virginia
- Petersburg National Battlefield, Virginia
- Shenandoah National Park, Virginia

1989-1990	Site Supervisor, SJS Archaeological Services, Inc., PA

Directed excavations on prehistoric sites.

Participation in:
- survey and excavation
- supervision of personnel
- field photography
- field recording

1982 Consulting Archaeologist, Longmeadow Historical Society, MA

1979-1980 Survey Director, Magee University College, New University of Ulster, Northern Ireland

Directed survey of 17th-century British village sites in County Londonderry, Ulster

1976-1978 Consulting Archaeologist, Historic Deerfield, MA

1973-1974 Supervisor and Field Excavator, Colonial Williamsburg, VA

Other Experience

1991 Teaching Assistant, Department of Geology and Earth Sciences, West Chester University, PA

1989-1990 Instructor/Graduate Assistant, Department of Anthropology, New York University, NY

Special Skills and Interests

- statistical analysis of survey and excavation data; statistical sampling; statistical analysis of anthropological data
- remote sensing: magnetometer and resistivity meter
- analysis of prehistoric lithics and historic ceramics
- computerization of survey, excavation and collections analysis data
- petrographic analysis of archaeological artifacts
- scanning electron microscopy and electron microprobe analysis
- photography of archaeological data related to electron microscopy and petrographic analysis, as well as of field and collection data

Publications

"English Villages in the Londonderry Plantation." Post-Medieval Archaeology 20: 257-269. 1986.

"Historic Archaeology and the Decorative Arts." CRM Bulletin 8(3&4):14, 15, 18. D. Campana and D. Orr, co-authors. 1985.

"Uncovering Early City Point, Virginia." Archaeology 38(3):64, 65, 78. D. Campana and D. Orr, co-authors. 1985.

"The Discovery of the Taylor House at the Petersburg National Battlefield." Historical Archaeology 18: 64-74. B. Bevan and D. Orr, co-authors. 1984.

"'In the Manner of England': Tenant Housing in the Londonderry Plantation." Ulster Folklife 27:39-56. 1981.

"Dungiven Bawn Re-edified." Ulster Journal of Archaeology 43:91-96. N. F. Brannon, co-author. 1980

"Archeological Excavations at George Washington Birthplace, 1974-1977." In Chapters in the History of Popes Creek Plantation, Washington's Birthplace: Wakefield Memorial Association, 1979.

"Dr Williams' Privy: Cultural Behavior as Reflected in Artifact Deposition at the Dr. Thomas Williams House, Deerfield, Massachusetts." In New England Historical Archaeology, Boston University, 1977.

Awards

National Science Foundation Dissertation Improvement Grant, 1993-94
Dean's Dissertation Fellowship, New York University, 1993-94
University Fellowship, New York University, 1988-90
Fulbright-Hayes Fellowship, Senior Research Scholar, New University of Ulster (Northern Ireland), 1979-80

Richard W. Hunter
PRESIDENT

Ian C. Burrow
VICE PRESIDENT

MICHAEL TOMKINS
Senior Archaeologist/Historian, BA

Education

B.A. Anthropology/Geography, State University of New York at Albany, Albany, New York, 1990.

Experience

1993 -	Senior Archaeologist/Historian, Hunter Research Inc., Trenton, NJ
1991 -	Assistant Historian/Assistant Archaeologist Hunter Research, Inc., Trenton, NJ Technical and supervisory responsibilities for selected historical and archival research tasks, field and laboratory operations and report preparation. Participation in: - archival and cartographic research - survey and excavation - supervision of field personnel - field photography - stratigraphic and artifact analysis - report preparation
1990	Crew Chief, New York State Museum, Division of Historic and Anthropological Services, Albany, New York Field archaeologist on cultural resource surveys on proposed construction projects of the New York State Department of Transportation and Department of Corrections.
1987-1989	Field Archaeologist, New York State Museum, Division of Historic and Anthropological Services, Albany, NY (June - September) Field archaeologist on various cultural resource survey projects in upper New York State.
1988	Field Archaeologist, Public Archaeological Facility, SUNY at Binghamton, New York (summer months) Field archaeologist participating in excavations of human burials from a late nineteenth century psychiatric hospital in upper New York State.

Other Experience

1990 -	New York State Emergency Medical Technician Certification Volunteer Emergency Technician for Town of Guilderland
1984 -	NAUI Basic Scuba Diver Certification

APPENDIX D

PROJECT ADMINISTRATIVE SUMMARY

APPENDIX D

PROJECT ADMINISTRATIVE SUMMARY

HUNTER RESEARCH, INC.
PROJECT SUMMARY

Project Name: A PHASE 1 SUBMERGED AND SHORELINE CULTURAL RESOURCES INVESTIGATION ABSECON ISLAND, ATLANTIC COUNTY, NEW JERSEY
Level of Survey: I
HRI Project: 94027
Date of Report: 1995, March

Client: U.S. Army Corps of Engineers
Address: The Wanamaker Building, 100 Penn Square East, Philadelphia, PA 19107-3390
Review Agency: NJSHPO
Agency Reference:

PROJECT CHRONOLOGY
Date of Contract Award: 07/14/1994
Notice to Proceed: 07/14/1994
Background Research: August-September, 1994
Fieldwork: August-September, 1994
Analysis: September-October, 1994
Report Written: December, 1994 & February-March, 1995

PROJECT PERSONNEL:
Principal Investigator: Richard Hunter
Background Research: Lee Cox, Michael Tomkins
Field Supervisor: Lee Cox, Michael Tomkins
Field Assistants: Wess Hall, Ralph Wilbanks, Don Stokes
Artifact Analysis: Lee Cox
Draftsperson: Jason Fantom, Vincent Maresca
Report Written By: Lee Cox, Richard Hunter, Brooke Blades, Michael Tomkins
Artifacts and Records to be Deposited: Dolan Research, Inc.

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EXECUTIVE SUMMARY

PHASE 1 AND 2 SUBMERGED AND SHORELINE CULTURAL RESOURCES INVESTIGATION
BRIGANTINE TO HEREFORD INLET,
ATLANTIC AND CAPE MAY COUNTIES, NEW JERSEY
ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT

CONTRACT DACW61-94-D-0010

Prepared for:
Hunter Research
714 S. Clinton Ave.
Trenton, N.J. 08611

by:
J. Lee Cox, Jr.
Dolan Research, Inc.
4425 Osage Avenue
Philadelphia, PA 19104

November 15, 1995

Introduction

The U. S. Army Corps of Engineers is studying erosion problems along the Atlantic Ocean shoreline of New Jersey from Brigantine Inlet to Hereford Inlet. This study includes the identification of potential beach nourishment locations and viable offshore borrow areas. In conjunction with this study, a Phase 1 and 2 underwater archaeological project was conducted to identify submerged historic and archaeological sites within the various project areas.

The investigation included Phase 1 remote sensing surveying, Phase 2 underwater investigation of six remote sensing target locations, and a shoreline survey. The project involved a wide variety of services including; background documentary research, acoustic, magnetic and bathymetric remote sensing, target analysis, a low tide shoreline investigation, and diving on six remote sensing targets. The goal of the project was to determine the presence or absence of submerged cultural resources potentially eligible for the National Register of Historic Places which might be affected by potential construction impacts. The underwater archaeological investigation was undertaken to assist in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended; the regulations of the Advisory Council on Historic Preservation (30 CFR Part 800); the National Environmental Policy Act of 1969, as amended; other applicable federal and state mandates; and Corps of Engineers regulations.

Description of Work Areas

All offshore fieldwork and diving investigations were completed on the Atlantic Ocean by a five person project crew from Dolan Research, Inc., between October 1 and 18, 1995. The project areas spanned across a 30 mile long portion of New Jersey's Atlantic Coast. The project involved three different work tasks; a remote sensing survey at seven locations, the ground truthing of six remote sensing targets located during a 1994 survey, and five shoreline investigations.

Coordinates for the corners of the seven survey areas are expressed in the New Jersey State Plane Coordinate System.

Site Name	Northings	Eastings
Brigantine (NAD 27)	224750	2097300
	225300	2100000
	219300	2098850
	219000	2096600
	222550	2096400
Absecon (NAD 83)	196238	520356
	194171	528509
	193638	522313

	195534	519763
Longport (NAD 27) (N. Great Egg Harbor)	169600	2038600
	170600	2040900
	166200	2042200
	165700	2041900
	167000	2040200
Townsend (NAD 83)	103456	431618
	103023	432100
	99349	435437
	97853	436641
	101580	437783
	102306	435561
	99314	435800
	102899	433896
	104130	432932
	103706	432604
	103733	431876
Seven Mile (NAD 83)	87070	442629
	86936	443503
	86106	443180
	78808	442836
	79772	440563
Great Channel (NAD 83)	75150	412284
	75150	413448
	74452	412483
	71229	409783
	71508	409454
Hereford (NAD 83)	67724	414081
	68441	416449
	61761	415631
	57325	412410
	58316	411243
	60705	412726
	62843	412594
	64302	413760
	66117	413888
	67052	413497

At each survey area, lane spacing was 75 feet, with coverage extending 75 beyond the defined boundaries of each area. Shallow water conditions along portions of the Brigantine and Hereford survey areas made safe navigation impossible across near-shore shoals. Surveying of those areas was completed at or near high tide. Remote sensing was limited to the portions of these areas that had a water depth exceeding 5.0 feet at mean high water.

Diving investigations of six (6) remote sensing targets was completed to identify the material responsible for generating the remote sensing signatures. Five of the targets were identified during a 1994 underwater archaeological investigation offshore of Absecon Inlet, and the sixth target (2:348), was identified during the initial phase of the present project. The following targets were investigated:

(1) 6:1005
(2) 7:1290
(3) 9:2273
(4) 11:2740
(5) 8:534
(6) 2:348

The third fieldwork task involved the completion of shoreline surveys along five beaches in southern New Jersey during low-tide. Those surveys will be completed in the near future.

Description of Fieldwork

All remote sensing fieldwork were carried out from a 25 foot survey vessel suitable for shoal and open water operations. A *Geometrics*, G-866, proton procession magnetometer, capable of +/- one gamma resolution, was employed to collect magnetic remote sensing data. A 2-second sampling rate by the magnetometer's towed sensor, coupled with a 3.5 to 4 knot vessel speed, assured a magnetic sample every 10 feet. A *Klein* two channel acoustic recorder with a 500 kHz side scan sensor was used to collect acoustic data. Acoustic data was recorded on wet chemical paper with an analog recorder. An Mardata precision echo depth sounder with a 208 kHz narrow beam transducer was used to collect bathymetric data. Survey vessel trackline control and position fixing were obtained by using a laptop PC-based software *(Hypack)* package in conjunction with a *Navstar* Differential Global Positioning System (DGPS) onboard the survey vessel. Differential corrections were obtained from Coast Guard beacons transmitting from Sandy Hook, New Jersey, and Cape Henlopen, Delaware. The onboard computer and black/white monitor were interfaced with the DGPS satellite positioning system. Positioning data from the DGPS was converted by the computer to Delaware NAD 83 X,Y coordinates in real time. These X,Y coordinates were used to guide the survey vessel precisely along predetermined tracklines. While surveying, vessel positions were continually updated on the computer monitor to assist the vessel operator, and the processed X,Y data were continually logged on computer disk for post processing and plotting. Positioning data for the relocation of 1994 targets were calculated in the New Jersey (NAD 83) state plane coordinate system.

Magnetic, acoustic and bathymetric data were collected simultaneously. Position coordinates and bathymetric data were logged into the onboard computer. To allow for the detection of subtle magnetic anomalies typically associated with smaller wooden vessels, survey lane spacing for the survey was established at 75 foot offsets. Since the side scanning sonar transducer has an effective range of more than 150 feet in each channel, 75 foot lane offsets provided comprehensive acoustic coverage for each area. A precise track plot was recorded for all survey lanes and remote sensing records were annotated at 150 foot intervals along each lane. This allowed researchers to rapidly integrate the acoustic and magnetic records into a survey map and to pinpoint the location of each identified target.

Magnetic data was contour plotted at 10 gamma intervals. Sonagram records were inspected for potential man-made features present on the bottom surface. After fieldwork data was collected, magnetic data was correlated with sonar and bathymetric records and targets of potential significance were identified and designated. Targets signatures located during the survey were refined to permit highly accurate positioning and to facilitate signature analysis.

Findings of the Remote Sensing Survey

Magnetic targets were identified according to several criteria. Magnetometer data were contour plotted and each anomaly analyzed according to: magnetic intensity (total distortion of the magnetic background measured in gammas); pulse duration (detectable signature duration); signature characteristics (negative monopolar, positive monopolar, dipolar, or multi-component); and spatial extent (total area of disturbance). Acoustic (side scan sonar) targets were analyzed according to their spatial extent, configuration, location and environmental context. Magnetic records were correlated with the acoustic targets and integrated with bathymetric data to provide comprehensive remote sensing information on the identity of the material generating the remote sensing signatures.

Although data analysis is presently being conducted, preliminary analysis of the remote sensing data has confirmed the existence of 43 remote sensing targets in the seven different survey locations. However, most of the targets have signature characteristics typically generated by modern debris, or single, isolated objects on the bottom. Following is a preliminary listing of targets identified during the remote sensing survey. Targets have been listed for each area according to three general types: High Probability Targets, which may require further archaeological investigation; Magnetic Targets with an associated Acoustic Target, and Magnetic-only targets. Upon more comprehensive analysis of the data, the number of targets may be reduced. Six high probability targets were identified in the Hereford Inlet survey area. One high probability target was identified in the Brigantine Inlet survey area, and two high probability targets were identified in the Absecon Inlet survey area (Target 2:348 was further investigated during this project).

NAME OF AREA	High Probability Targets	Mag/Acoustic Targets	Mag Only Targets	Total Targets in Area
Brigantine	1	0	1	1
Absecon	2	0	4	4
Longport (N. Great Egg Harbor Inlet)	0	0	1	1
Seven	0	0	0	0
Townsend	0	0	12	12
Great Channel	0	0	3	3
Hereford	6	6	16	22
TOTALS	9	6	37	43

Findings of the Target Investigations

A 1994 investigation of two borrow areas off Absecon Inlet identified five magnetic targets that generated remote sensing signatures that are suggestive of submerged cultural resources. A sixth target (2:348), identified during the first phase of the present project, was added to list of targets to be investigated. Each of the target signatures was first reacquired; then a series of closely spaced survey lanes were completed around the target location to gather more detailed structural information on the target location. Divers then entered the water at the center of the target location during a slack tide to confirm the nature of the material responsible for generating the remote sensing signature. Following is a brief summary of the diving activities at each of the six target locations:

Target 6:1005

Coordinates (NAD 83): N 196450
E 517794

The target is located within Absecon Inlet, on the north side of the navigational channel. A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a large dipolar anomaly. The anomaly had a maximum magnetic distortion of 607 gammas and influence from the ferrous source of the signature extended across an area approximately 70 feet long by 25 feet wide. The object generating the anomaly is oriented parallel with the navigational channel through Absecon Inlet. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. After divers failed to identify any material on the bottom surface, a systematic sub-bottom search was conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. A brief effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. However, the brief 15-20 minutes of slack water between tides did not allow adequate time to effectively search with the jet probe. Strong tidal currents were observed at the target site during all phases of the tidal cycle with the exception of slack water between tidal changes.

Although the source of the anomaly was not identified by divers, magnetic signature characteristics are strongly suggestive of a small ship/boat wreck site. The site is apparently buried beneath at least four feet of sediment. If avoidance within a 100 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

Target 7:1290

Coordinates (NAD 83): N 192478
E 520386

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a monopolar anomaly that had two related peaks of intensity. The anomaly had a maximum magnetic distortion of 216 gammas and influence from the ferrous source of the signature extended across an area approximately 100 feet long by 25 feet wide. The object generating the anomaly is located approximately 150 feet from the red channel buoy #4. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. After divers failed to identify any material on the bottom surface, a systematic sub-bottom search was conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. Divers then used a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. However, the brief 15-20 minutes of slack water between tides did not allow adequate time to effectively search with the jet probe. Strong tidal currents were observed at the target site during all phases of the tidal cycle with the exception of slack water between tidal changes.

Signature characteristics observed during the re-acquisition of the target location are suggestive of cable, pipe, or possibly chain. The target may have some association with a former navigational buoy at this location. The target signature is not considered to be associated with a shipwreck site and no additional underwater archaeological investigation is recommended at this location.

Target 9:2273

Coordinates (NAD 83): N 194854
E 519203

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a small dipolar anomaly. The isolated anomaly had a maximum magnetic distortion of 93 gammas and influence from the ferrous source of the signature extended across an area approximately 40 feet long by 20 feet wide. The object generating the anomaly is located on a shoal opposite the end of the jetty on the north side of Absecon Inlet that had breaking seas during much of the tidal cycle. After a detailed grid of survey lanes was completed at the target location, it was determined that the target was a small, isolated object. The signature was not suggestive of a submerged cultural resource. No additional underwater archaeological investigation is recommended at this location.

Target 11:2740

Coordinates (NAD 83): N 193009
E 520458

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a large, noisey dipolar anomaly. The anomaly had a maximum magnetic distortion of 1,315 gammas and influence from the ferrous source of the signature extended across an area approximately 120 feet long by 35 feet wide.

The object generating the anomaly is oriented parallel with the navigational channel coming out of Absecon Inlet. The target site is located on a shoal where large ocean swells occasionally broke into rolling seas during low tides. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Working at or near high tide, divers failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. A brief effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. Divers, after struggling against tidal currents briefly made contact with a hard object under more than eight feet of sand. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Although the source of the anomaly was not identified by divers, magnetic signature characteristics are strongly suggestive of a ship/boat wreck site. The site is apparently buried beneath approximately eight feet of sand. If avoidance within a 150 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

Target 8:534

Coordinates (NAD 83): N 193709
E 521521

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of an extremely large, dipolar anomaly. The anomaly had a maximum magnetic distortion of 8,297 gammas and influence from the ferrous source of the signature extended across an area approximately 250 feet long by 60 feet wide.

The object generating the anomaly is oriented parallel with the navigational channel coming out of Absecon Inlet. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Divers initially failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. An effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. A series of contacts were recorded with a hard, metal object at a depth that varied from seven to nine feet deep in the sand. Probe contacts were recorded across a width approximately 35 feet wide. Depths of the contacts increased on either side, suggesting that the target may be associated with an inverted hull of a ship or fishing trawler. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Probing investigations confirm the presence of a deeply buried object that matches the configuration of an inverted ship's hull. The site is apparently buried beneath at least seven feet of sand. The magnetic signature indicates the presence of a large object in excess of 200 feet long. If avoidance within a 300 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

Target 2:348

Coordinates (NAD 83): N 196040
E 521075

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a dipolar anomaly. The anomaly had a maximum magnetic distortion of 439 gammas and influence from the ferrous source of the signature extended across an area approximately 90 feet long by 25 feet wide.

The object generating the anomaly is oriented parallel with the Brigantine Beach shoreline. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Divers initially failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. An effort was made to deploy a six-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. A series of contacts were recorded with wood structures and metal objects at a depth that varied from four to six feet deep in the sand. Probe contacts were recorded across an area approximately 25 feet long. By using the jet probe, divers were able to briefly reach wood planking, and metal strapping at the site. The site appears to be a small wooden hull vessel that had machinery and other ferrous objects associated with it. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Probing investigations confirm the presence of a a buried object that matches the configuration of relatively small ship's hull. The site is apparently buried beneath at least five feet of sand. The magnetic signature indicates the presence of a large object in excess of 75 feet long. If avoidance within a 150 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

EXECUTIVE SUMMARY

PHASE 1 AND 2 SUBMERGED AND SHORELINE CULTURAL RESOURCES
INVESTIGATION
BRIGANTINE TO HEREFORD INLET,
ATLANTIC AND CAPE MAY COUNTIES, NEW JERSEY
ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT

CONTRACT DACW61-94-D-0010

Prepared for:
Hunter Research
714 S. Clinton Ave.
Trenton, N.J. 08611

by:
J. Lee Cox, Jr.
Dolan Research, Inc.
4425 Osage Avenue
Philadelphia, PA 19104

November 15, 1995

Introduction

The U. S. Army Corps of Engineers is studying erosion problems along the Atlantic Ocean shoreline of New Jersey from Brigantine Inlet to Hereford Inlet. This study includes the identification of potential beach nourishment locations and viable offshore borrow areas. In conjunction with this study, a Phase 1 and 2 underwater archaeological project was conducted to identify submerged historic and archaeological sites within the various project areas.

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Description of Work Areas

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	193638	522313

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	166200	2042200
	165700	2041900
	167000	2040200
Townsend (NAD 83)	103456	431618
	103023	432100
	99349	435437
	97853	436641
	101580	437783
	102306	435561
	99314	435800
	102899	433896
	104130	432932
	103706	432604
	103733	431876
Seven Mile (NAD 83)	87070	442629
	86936	443503
	86106	443180
	78808	442836
	79772	440563
Great Channel (NAD 83)	75150	412284
	75150	413448
	74452	412483
	71229	409783
	71508	409454
Hereford (NAD 83)	67724	414081
	68441	416449
	61761	415631
	57325	412410
	58316	411243
	60705	412726
	62843	412594
	64302	413760
	66117	413888
	67052	413497

At each survey area, lane spacing was 75 feet, with coverage extending 75 beyond the defined boundaries of each area. Shallow water conditions along portions of the Brigantine and Hereford survey areas made safe navigation impossible across near-shore shoals. Surveying of those areas was completed at or near high tide. Remote sensing was limited to the portions of these areas that had a water depth exceeding 5.0 feet at mean high water.

Diving investigations of six (6) remote sensing targets was completed to identify the material responsible for generating the remote sensing signatures. Five of the targets were identified during a 1994 underwater archaeological investigation offshore of Absecon Inlet, and the sixth target (2:348), was identified during the initial phase of the present project. The following targets were investigated:

(1) 6:1005
(2) 7:1290
(3) 9:2273
(4) 11:2740
(5) 8:534
(6) 2:348

The third fieldwork task involved the completion of shoreline surveys along five beaches in southern New Jersey during low-tide. Those surveys will be completed in the near future.

Description of Fieldwork

All remote sensing fieldwork were carried out from a 25 foot survey vessel suitable for shoal and open water operations. A *Geometrics*, G-866, proton procession magnetometer, capable of +/- one gamma resolution, was employed to collect magnetic remote sensing data. A 2-second sampling rate by the magnetometer's towed sensor, coupled with a 3.5 to 4 knot vessel speed, assured a magnetic sample every 10 feet. A *Klein* two channel acoustic recorder with a 500 kHz side scan sensor was used to collect acoustic data. Acoustic data was recorded on wet chemical paper with an analog recorder. An Mardata precision echo depth sounder with a 208 kHz narrow beam transducer was used to collect bathymetric data. Survey vessel trackline control and position fixing were obtained by using a laptop PC-based software *(Hypack)* package in conjunction with a *Navstar* Differential Global Positioning System (DGPS) onboard the survey vessel. Differential corrections were obtained from Coast Guard beacons transmitting from Sandy Hook, New Jersey, and Cape Henlopen, Delaware. The onboard computer and black/white monitor were interfaced with the DGPS satellite positioning system. Positioning data from the DGPS was converted by the computer to Delaware NAD 83 X,Y coordinates in real time. These X,Y coordinates were used to guide the survey vessel precisely along predetermined tracklines. While surveying, vessel positions were continually updated on the computer monitor to assist the vessel operator, and the processed X,Y data were continually logged on computer disk for post processing and plotting. Positioning data for the relocation of 1994 targets were calculated in the New Jersey (NAD 83) state plane coordinate system.

Magnetic, acoustic and bathymetric data were collected simultaneously. Position coordinates and bathymetric data were logged into the onboard computer. To allow for the detection of subtle magnetic anomalies typically associated with smaller wooden vessels, survey lane spacing for the survey was established at 75 foot offsets. Since the side scanning sonar transducer has an effective range of more than 150 feet in each channel, 75 foot lane offsets provided comprehensive acoustic coverage for each area. A precise track plot was recorded for all survey lanes and remote sensing records were annotated at 150 foot intervals along each lane. This allowed researchers to rapidly integrate the acoustic and magnetic records into a survey map and to pinpoint the location of each identified target.

Magnetic data was contour plotted at 10 gamma intervals. Sonagram records were inspected for potential man-made features present on the bottom surface. After fieldwork data was collected, magnetic data was correlated with sonar and bathymetric records and targets of potential significance were identified and designated. Targets signatures located during the survey were refined to permit highly accurate positioning and to facilitate signature analysis.

Findings of the Remote Sensing Survey

Magnetic targets were identified according to several criteria. Magnetometer data were contour plotted and each anomaly analyzed according to: magnetic intensity (total distortion of the magnetic background measured in gammas); pulse duration (detectable signature duration); signature characteristics (negative monopolar, positive monopolar, dipolar, or multi-component); and spatial extent (total area of disturbance). Acoustic (side scan sonar) targets were analyzed according to their spatial extent, configuration, location and environmental context. Magnetic records were correlated with the acoustic targets and integrated with bathymetric data to provide comprehensive remote sensing information on the identity of the material generating the remote sensing signatures.

Although data analysis is presently being conducted, preliminary analysis of the remote sensing data has confirmed the existence of 43 remote sensing targets in the seven different survey locations. However, most of the targets have signature characteristics typically generated by modern debris, or single, isolated objects on the bottom. Following is a preliminary listing of targets identified during the remote sensing survey. Targets have been listed for each area according to three general types: High Probability Targets, which may require further archaeological investigation; Magnetic Targets with an associated Acoustic Target, and Magnetic-only targets. Upon more comprehensive analysis of the data, the number of targets may be reduced. Six high probability targets were identified in the Hereford Inlet survey area. One high probability target was identified in the Brigantine Inlet survey area, and two high probability targets were identified in the Absecon Inlet survey area (Target 2:348 was further investigated during this project).

NAME OF AREA	High Probability Targets	Mag/Acoustic Targets	Mag Only Targets	Total Targets in Area
Brigantine	1	0	1	1
Absecon	2	0	4	4
Longport (N. Great Egg Harbor Inlet)	0	0	1	1
Seven	0	0	0	0
Townsend	0	0	12	12
Great Channel	0	0	3	3
Hereford	6	6	16	22
TOTALS	9	6	37	43

Findings of the Target Investigations

A 1994 investigation of two borrow areas off Absecon Inlet identified five magnetic targets that generated remote sensing signatures that are suggestive of submerged cultural resources. A sixth target (2:348), identified during the first phase of the present project, was added to list of targets to be investigated. Each of the target signatures was first reacquired; then a series of closely spaced survey lanes were completed around the target location to gather more detailed structural information on the target location. Divers then entered the water at the center of the target location during a slack tide to confirm the nature of the material responsible for generating the remote sensing signature. Following is a brief summary of the diving activities at each of the six target locations:

Target 6:1005

Coordinates (NAD 83): N 196450
E 517794

The target is located within Absecon Inlet, on the north side of the navigational channel. A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a large dipolar anomaly. The anomaly had a maximum magnetic distortion of 607 gammas and influence from the ferrous source of the signature extended across an area approximately 70 feet long by 25 feet wide. The object generating the anomaly is oriented parallel with the navigational channel through Absecon Inlet. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. After divers failed to identify any material on the bottom surface, a systematic sub-bottom search was conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. A brief effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. However, the brief 15-20 minutes of slack water between tides did not allow adequate time to effectively search with the jet probe. Strong tidal currents were observed at the target site during all phases of the tidal cycle with the exception of slack water between tidal changes.

Although the source of the anomaly was not identified by divers, magnetic signature characteristics are strongly suggestive of a small ship/boat wreck site. The site is apparently buried beneath at least four feet of sediment. If avoidance within a 100 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

<u>Target 7;1290</u>

Coordinates (NAD 83): N 192478
E 520386

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a monopolar anomaly that had two related peaks of intensity. The anomaly had a maximum magnetic distortion of 216 gammas and influence from the ferrous source of the signature extended across an area approximately 100 feet long by 25 feet wide. The object generating the anomaly is located approximately 150 feet from the red channel buoy #4. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. After divers failed to identify any material on the bottom surface, a systematic sub-bottom search was conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. Divers then used a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. However, the brief 15-20 minutes of slack water between tides did not allow adequate time to effectively search with the jet probe. Strong tidal currents were observed at the target site during all phases of the tidal cycle with the exception of slack water between tidal changes.

Signature characteristics observed during the re-acquisition of the target location are suggestive of cable, pipe, or possibly chain. The target may have some association with a former navigational buoy at this location. The target signature is not considered to be associated with a shipwreck site and no additional underwater archaeological investigation is recommended at this location.

Target 9:2273

Coordinates (NAD 83): N 194854
E 519203

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a small dipolar anomaly. The isolated anomaly had a maximum magnetic distortion of 93 gammas and influence from the ferrous source of the signature extended across an area approximately 40 feet long by 20 feet wide. The object generating the anomaly is located on a shoal opposite the end of the jetty on the north side of Absecon Inlet that had breaking seas during much of the tidal cycle. After a detailed grid of survey lanes was completed at the target location, it was determined that the target was a small, isolated object. The signature was not suggestive of a submerged cultural resource. No additional underwater archaeological investigation is recommended at this location.

Target 11:2740

Coordinates (NAD 83): N 193009
E 520458

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a large, noisey dipolar anomaly. The anomaly had a maximum magnetic distortion of 1,315 gammas and influence from the ferrous source of the signature extended across an area approximately 120 feet long by 35 feet wide.

The object generating the anomaly is oriented parallel with the navigational channel coming out of Absecon Inlet. The target site is located on a shoal where large ocean swells occasionally broke into rolling seas during low tides. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Working at or near high tide, divers failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. A brief effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. Divers, after struggling against tidal currents briefly made contact with a hard object under more than eight feet of sand. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Although the source of the anomaly was not identified by divers, magnetic signature characteristics are strongly suggestive of a ship/boat wreck site. The site is apparently buried beneath approximately eight feet of sand. If avoidance within a 150 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

Target 8:534

Coordinates (NAD 83): N 193709
E 521521

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of an extremely large, dipolar anomaly. The anomaly had a maximum magnetic distortion of 8,297 gammas and influence from the ferrous source of the signature extended across an area approximately 250 feet long by 60 feet wide.

The object generating the anomaly is oriented parallel with the navigational channel coming out of Absecon Inlet. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Divers initially failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. An effort was made to deploy a ten-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. A series of contacts were recorded with a hard, metal object at a depth that varied from seven to nine feet deep in the sand. Probe contacts were recorded across a width approximately 35 feet wide. Depths of the contacts increased on either side, suggesting that the target may be associated with an inverted hull of a ship or fishing trawler. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Probing investigations confirm the presence of a deeply buried object that matches the configuration of an inverted ship's hull. The site is apparently buried beneath at least seven feet of sand. The magnetic signature indicates the presence of a large object in excess of 200 feet long. If avoidance within a 300 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

Target 2:348

Coordinates (NAD 83): N 196040
E 521075

A detailed magnetic remote sensing survey of the target vicinity confirmed the presence of a dipolar anomaly. The anomaly had a maximum magnetic distortion of 439 gammas and influence from the ferrous source of the signature extended across an area approximately 90 feet long by 25 feet wide.

The object generating the anomaly is oriented parallel with the Brigantine Beach shoreline. After a grid of survey lanes was completed at the target site, a buoy was placed at the center-point of the anomaly. Divers initially failed to identify any material on the bottom surface. A systematic sub-bottom search was then conducted with four-foot long hand held probes. Divers, working in a circle pattern with increasing diameters away from the target buoy, were again unable to contact the material which generated the magnetic anomaly. An effort was made to deploy a six-foot long water-powered jet probe to record sub-bottom contacts deeper than four feet. A series of contacts were recorded with wood structures and metal objects at a depth that varied from four to six feet deep in the sand. Probe contacts were recorded across an area approximately 25 feet long. By using the jet probe, divers were able to briefly reach wood planking, and metal strapping at the site. The site appears to be a small wooden hull vessel that had machinery and other ferrous objects associated with it. Additional investigation of a site buried beneath that amount of sand was not logistically possible during the present project.

Probing investigations confirm the presence of a a buried object that matches the configuration of relatively small ship's hull. The site is apparently buried beneath at least five feet of sand. The magnetic signature indicates the presence of a large object in excess of 75 feet long. If avoidance within a 150 foot radius (from the coordinates listed above) is not an option, it is recommended that future dredging operations in the target vicinity be monitored to address potential impact on the site.

APPENDIX D

PERTINENT CORRESPONDENCE

615

Post-it® Fax Note 7671	Date 8/26/96 # of pages ▸ 3
To John Burnes	From Richard Kropp
Co./Dept. COE	Co. NJDEP
Phone # 215-656-6540	Phone # 609-984-3444
Fax # 215-656-6543	Fax # 609-292-8115

State of

Department of En

Christine Todd Whitman
Governor

Commissioner

August 26, 1996

Robert L. Callegari
Planning Division
Department of the Army
Philadelphia District
Philadelphia, Pennsylvania 19107

RE: Water Quality Certification and Federal Consistency Statement Request.
Absecon Island Dredging/Beach Fill Study
LURP File No. 0000-96-0002.2
Atlantic City, Ventnor, Margate and Longport
Atlantic County

Dear Mr. Callegari:

The New Jersey Department of Environmental Protection, Land Use Regulation Program, acting under Section 307 of the Federal Coastal Zone Management Act (P.L. 92-583) as amended, has reviewed the "Absecon Island Interim Feasibility Study, Volume 1," dated April 1996. Based on the information submitted the Program has determined that the project as discussed in the submitted feasibility study, is consistent with New Jersey's Rules on Coastal Zone Management, N.J.A.C. 7:7E, as amended to August 19, 1996 and the applicable Rules guiding issuance of a Section 401 Water Quality Certificate, provided the conditions discussed below are met to the satisfaction of the Department.

<u>Project Description</u>

The project is intended to provide storm and erosion protection for the coastal communities of Atlantic City, Ventnor, Margate and Longport. The project includes the dredging and placement of sand on the beach with a periodic replenishment of dredged sand every 3 years over a 50 year project life. In addition, the plan provides for bulkheads at unprotected areas of the Absecon Inlet frontage.

This consistency determination is based on the following conditions being met:

1. In Atlantic City, the selected plan berm width of 200 feet which maximizes net benefits from a federal standpoint may be less desirable than a lesser scale plan with potentially less environmental impact but approaching the selected alternative in storm damage protection. Since the destruction of surf clam areas is prohibited (7:7E-3.3), in order to reduce impacts to surf clam areas, an alternative with a lesser berm width (150', Alternatives CX or CY) must be implemented unless sufficient information is provided to demonstrate that these alternatives do not fulfill the project purpose or do not reduce impact to surf clam areas.

2. The proposed bulkhead sections should be located behind the beach and above the spring high water line in order to met the Rules concerning Beaches (7:7E-3.22), Intertidal and Subtidal Shallows (7:7E-3.15), Filling (7:7E-4.2(j)) and Coastal Engineering (Structural Shore Protection Structures) (7:7E-7.11(e)). Coordination with the Land Use Regulation Program during design studies must be accomplished to determine an alignment which meets these rules.

3. In order to meet the Surf Clam Areas Rule (7:7E-3.3), either utilize, or provide specifics which justify, to the Program's satisfaction, dismissing the use of, the interior of the Absecon Inlet site along Brigantine to reduce the destruction of surf clam areas. The information provided should evaluate areas outshore of the beaches and dunes. The information should also include a characterization of the substrate materials.

4. Locations and plans for access through the dunes must be provided in accordance with the requirements set forth in the Dune rule (7:7E-3.16) and the standards set forth at Subchapter 3A that are applicable.

5. The Army Corps of Engineers is required to provide the monitoring plan as described in the submitted feasibility study (page 202, paragraph 492) within 30 days of the date when the first funds for preconstruction engineering and design are received in the district. This monitoring plan was not included in the feasibility study. The monitoring plan must provide for the assessment of recolonization of the borrow area by surf clams.

6. In order to reduce the loss of surf clam areas, prior to deciding where to obtain borrow material for future beach replenishment, the previously used portions of the borrow area shall be evaluated and the expansion into unused portions of the borrow area restricted.

Revised plans and supporting information for each of the above conditions must be submitted to the Land Use

Regulation Program for review and approval at least 90 days prior to soliciting bids on the project.

Pursuant to 15 CFR 930.44, the Program reserves the right to object and request remedial action if this project is conducted in a manner, or is having an effect on, the coastal zone which is substantially different than originally proposed.

If you have any questions concerning this determination please contact Catherine Krause, of my staff, at the above address or at (609) 984-0288.

Sincerely,

Richard Kropp, Director
Land Use Regulation Program

cc: Lawrence Schmidt
James Hall, Assistant Commissioner

HORN, KAPLAN, GOLDBERG, GORNY & DANIELS
A PROFESSIONAL CORPORATION
COUNSELLORS AT LAW
SUITE 500 CITICENTER BUILDING
1300 ATLANTIC AVENUE
ATLANTIC CITY, NEW JERSEY 08401-7278
TELEPHONE (609) 348-4515
FACSIMILE (609) 348-6834

LAURELWOOD, SUITE 153
1200 LAUREL OAK ROAD
VOORHEES, NEW JERSEY 08043-4317
TELEPHONE (609) 346-8600
FACSIMILE (609) 346-9866

TWO TOWER CENTER
10TH FLOOR
EAST BRUNSWICK, NEW JERSEY 08816-9884
TELEPHONE (908) 846-1700
FACSIMILE (908) 247-6328

DIRECT DIAL: 343-7804

REPLY TO: Atlantic City

November 1, 1991

NOV 05 1991

Congressman William Hughes
Central Park East
Building 4, Suite 5
222 New Road
Linwood, New Jersey 08221

Dear Congressman Hughes:

I've been following with great interest your success with the Cape May City Beach Replenishment Project and the soon to occur Great Egg Harbor Inlet dredging and replenishment of Ocean City beaches.

We who live on the Point in Longport, New Jersey across Great Egg Harbor from Ocean City have faced a rapidly deteriorating problem with the beaches on the bay side of the Point where the sand has been completely stripped away and we are rapidly approaching the bottom limit of our bulkheads. If there were any potential to pump sand from the dredging of Great Egg Harbor Inlet to that side of Longport as well as the beaches in Ocean City we would be eternally grateful.

I also would like to voice my opinion that the only thing that's going to stabilize Ocean City's beaches as well as Longport beaches is to create a real inlet such as the Atlantic City Inlet which in the short term is expensive, but would save

---

money over the future, since you would not have to constantly redredge Great Egg Harbor Inlet, or protect the beaches or both sides of the inlet.

I would appreciate a response and I'd also like to know when the public hearings are proposed for the dredging of Great Egg Harbor Inlet and the Ocean City Beach Replenishment Project.

Thank you.

Very truly yours,

John Walker Daniels

1101 Atlantic Avenue
Longport, New Jersey 08403

JWD/sc

US Army Corps of Engineers
Philadelphia District

News Clips

Public Affairs Office

Atlantic City, N.J. Press Oct. 4, 1994

Battle for beaches goes on in A.C.

■ The city has been building up dunes and planting dune grasses. The work seems to slow the losses, but the beaches are still getting thinner. New weapons are being sought, such as pumps that will move sand from under the Boardwalk into bags that would anchor dunes.

By MICHAEL PRITCHARD
Staff Writer

ATLANTIC CITY — City workers have been bracing for another winter of northeasters to prevent more of the city's most valuable resource — the beaches — from slipping away with the tide.

But while the city has once again lined its beaches with dunes and dune grass, officials say it's only a matter of time before man will have to replace what nature took away.

"We are definitely going to need a major beach replenishment project eventually," said Robert Levy, city Beach Patrol chief. "We are in the Army Corps of Engineers replenishment program, but unfortunately it could be up to four years before they can get to us.

"In the meantime all we can do is try and fight the erosion with the dunes and the dune grass," Levy said.

The first test came last weekend as Hurricane Gordan churned up strong surf along the eastern seaboard.

The city's network of dunes held up well.

"We didn't make out too badly at all," Levy said. "In some areas we lost the fronts of the dunes. But they've been built back up. Now we just have to see how they hold up in the next storm."

The city creates the dunes from sand that washes under the Boardwalk, to form a barrier to keep waves from damaging the wooden way. To bolster the dunes, dune grass is planted. The grass, however, needs time to take hold and

See Sand, Page C4

'We are definitely going to need a major beach replenishment project eventually. ... In the meantime all we can do is try and fight the erosion with the dunes and the dune grass.'

Robert Levy, Beach Patrol chief

Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Phone: (215) 656-6516

COMMITTEE ON THE JUDICIARY
SUBCOMMITTEE ON INTELLECTUAL PROPERTY AND JUDICIAL ADMINISTRATION (CHAIRMAN)
COMMITTEE ON MERCHANT MARINE AND FISHERIES
SELECT COMMITTEE ON AGING
SUBCOMMITTEE ON RETIREMENT INCOME AND EMPLOYMENT (CHAIRMAN)
SELECT COMMITTEE ON NARCOTICS ABUSE AND CONTROL

Congress of the United States
House of Representatives
Washington, DC 20515

DISTRICT OFFICES:
CENTRAL PARK EAST
BUILDING 4, SUITE 3
222 NEW ROAD
LINWOOD, NJ 08221
(609) 927-9063

151 NORTH BROADWAY
P.O. BOX 248
PENNSVILLE, NJ 08070
(609) 678-3333

November 8, 1991

Mr. John Walker Daniels, Esq.
1101 Atlantic Avenue
Longport, NJ 08403

Dear Mr. Daniels:

Thank you for your letter regarding the need for inlet and beach stabilization in Longport and Ocean City along the Great Egg Harbor Inlet.

As you noted, I have been actively involved with both the Army Corps of Engineers and the New Jersey Department of Environmental Protection and Energy to secure funds for dredging and beach nourishment projects. These agencies understand our problems and, within the constraints of their limited resources, they have been very responsive to our needs.

I appreciate your comments regarding methods to improve conditions in the vicinity of the Great Egg Harbor Inlet. The Corps of Engineers is conducting a New Jersey Shoreline Study to consider such issues and I have asked them to review your suggestions.

With kindest regards,

Sincerely,

William J. Hughes
Member of Congress

WJH:jhm
cc: Lieutenant Colonel Kenneth Clow

PLEASE RESPOND TO:
WASHINGTON ✓LINWOOD

619

JAN 27 1992

Civil Project Management Branch

Honorable William J. Hughes
Representative in Congress
Central Park East
Building 4, Suite 3
222 New Road
Linwood, New Jersey 08221

Dear Mr. Hughes:

This is in reference to your letter dated November 3, [illegible] to Mr. John Walker Daniels, Esq. regarding the need for inlet and [illegible] stabilization in Longport and Ocean City along Great Egg Harbor Inlet.

As you are aware, the Great Egg Harbor Inlet and Peck Beach Project was reauthorized by Section 501(a) of the Water Resources Development Act of 1986. The ongoing project is to provide initial beachfill and periodic nourishment for shore protection in Ocean City using material dredged from the Great Egg Harbor Inlet ebb shoal, approximately 3,000 feet offshore. The current project will not include dredging of the inlet for navigation purposes, and therefore there is no sand available from inlet dredging to be pumped onto the beaches at Longport, as Mr. Walker suggests. Public workshops and meetings and agency coordination were conducted for the project, culminating in the completion of the General Design Memorandum and Final Supplemental Environmental Impact Statement for the project in April 1989. As part of the planning process in that report, jetties for Great Egg Harbor Inlet were considered. It was determined that such structures would incur a prohibitively high cost due to the length of structures required in comparison to minor beneficial returns.

The Corps of Engineers is currently conducting a New Jersey Shore Protection Study. The purpose of this study is to investigate shore protection and water quality problems along the New Jersey coast extending from Sandy Hook to Cape May Point. We completed the limited reconnaissance phase of the New Jersey Shore Protection Study in September, 1990. As a result of that phase, we recommended six full reconnaissance studies. Longport is included in the study area from Brigantine Inlet to Great Egg Harbor Inlet. That reconnaissance was initiated in February 1991. The lack of protected beach berm and dunes in Longport was noted in the limited Reconnaissance Report and was again inspected during the present study and after the October 31, 1991 and January 5, 1992 coastal storms.

If we may be of any further assistance, please do not hesitate to contact us.

Sincerely,

Kenneth R. Clow
Lieutenant Colonel, Corps of Engineers
District Engineer

Copy Furnished:

Honorable William J. Hughes
House of Representatives
Washington, DC 20515

CENAP-DE
CENAP-PA
CENAP-PL-PC
CENAP-PL (Ferguson)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3391

REPLY TO
ATTENTION OF

Planning Division

JUN [illegible] 1993

NOTICE OF STUDY INITIATION

This notice is to announce the feasibility phase initiation of the Brigantine Inlet to Great Egg Harbor Inlet reach of the New Jersey Shore Protection Study. The Corps of Engineers is conducting this study in response to resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December, 1987. This study is being sponsored by the New Jersey Department of Environmental Protection and Energy (NJDEPE).

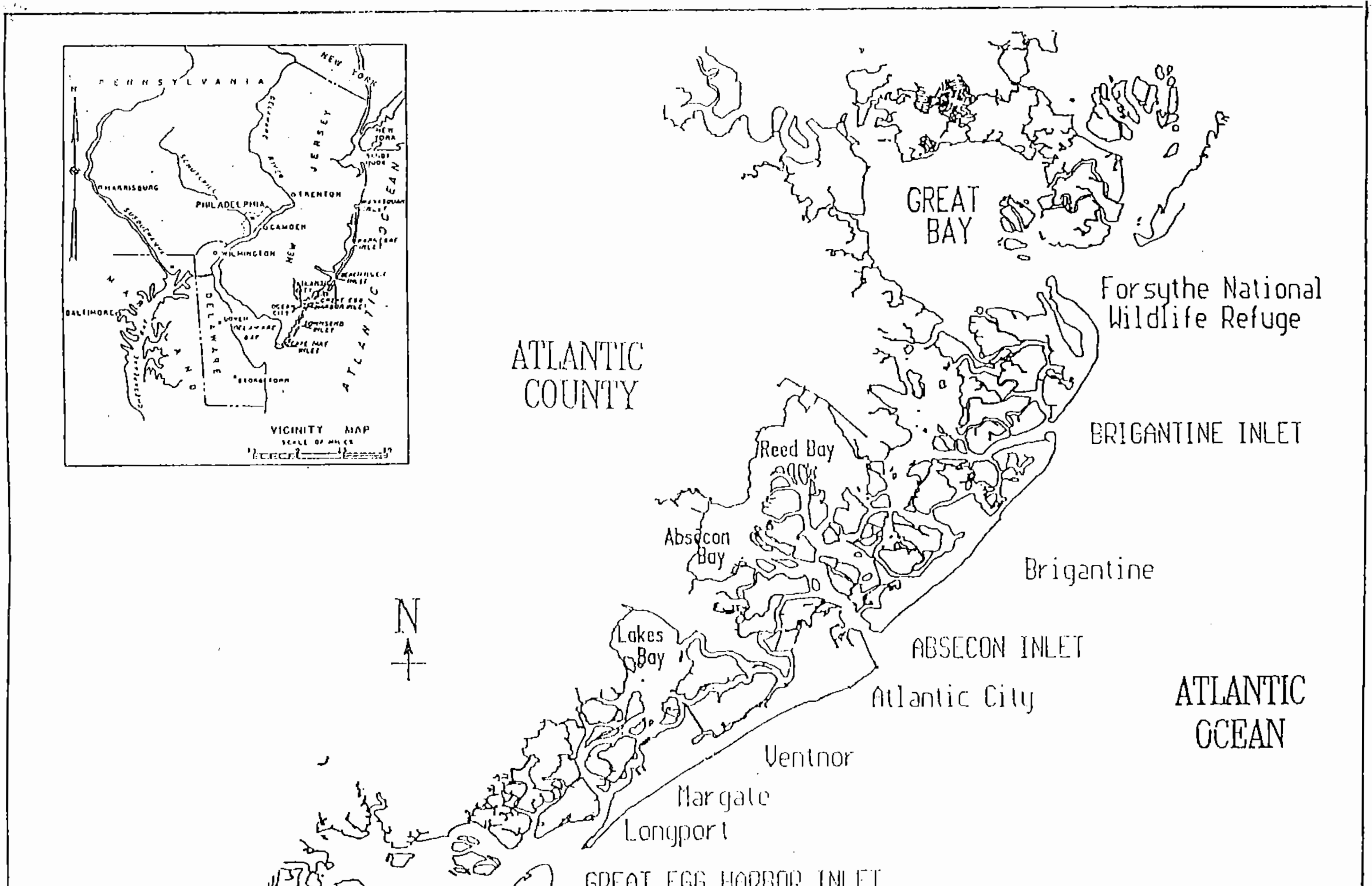
The purpose of the study is to investigate shoreline erosion and storm damage problems along the Atlantic coast of New Jersey with a view to providing shore protection, beach erosion control, hurricane protection, and environmental analysis of ecologically important areas. The study will collect a physical and environmental database of coastal area changes and processes, including appropriate monitoring during development of the database, as the basis for actions to prevent the harmful effects of further shoreline erosion and storm damage.

The first phase of the study, the reconnaissance phase, was completed in 1992 at 100% Federal cost. The reconnaissance phase established that there is Federal interest in establishing shoreline protection measures along the Atlantic coast of New Jersey for both Brigantine and Absecon Islands. The feasibility phase began on 1 March 1993 and is being cost shared 50%-50% between the State of New Jersey (NJDEPE) and the Federal government. The feasibility study will investigate shore protection problems, develop detailed solutions and an economic assessment of the viability of each chosen solution. Additionally, the feasibility study will include an assessment on the level of interest and support of non-Federal parties in the identified potential solutions, and establish the scope and schedule for the construction of future shore protection measures.

Any pertinent information that Federal, State or local agencies and the private sector can provide will be used to the greatest extent possible. We welcome any assistance and suggestions pertaining to the conduct of this study. All comments should be directed to the above address, ATTN: CENAP-PL-PC.

James F. Hall
Assistant Commissioner
New Jersey Department of
Environmental Protection and Energy

R.F. Sliwoski, P.E.
Lieutenant Colonel,
Corps of Engineers
District Engineer



New Jersey Shore Protection Study

BRIGANTINE INLET TO GREAT EGG HARBOR INLET

Scale = 1 :245,000

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COUNSELLORS AT LAW
SUITE 500 CITICENTER BUILDING
1300 ATLANTIC AVENUE
ATLANTIC CITY, NEW JERSEY 08401-7278
TELEPHONE (609) 348-4515
FACSIMILE (609) 348-6834

LAURELWOOD SUITE 155
1200 LAUREL OAK ROAD
VOORHEES, NEW JERSEY 08043-4317
TELEPHONE (609) 346-8600
FACSIMILE (609) 346-9866

July 14, 1993

REPLY TO: ATLANTIC CITY

Department of the Army
Philadelphia District Corps of Engineers
Wanamaker Building
100 Penn Square, East
Philadelphia, PA 19107-3391
Attn: CENAP-PL-PC

Dear Sir:

Please note that I live on Great Egg Harbor Inlet in Longport, New Jersey. My house is the last house on Atlantic Avenue on the bayside of Longport. Due to its location, I have had a wonderful opportunity to observe shoreline erosion and storm damage.

At the present time, we are experiencing a period of beach build-up and for the first summer in the last several years, we have a definite beach and protection behind our house. I attribute this to whatever changes have been made in the inlet by the dredging maintenance program, and I would invite you at any time to use our property as a monitoring point or whatever else you would like to experiment with in an attempt to identify potential solutions for shore protection measures.

I can be reached at anytime at the above address and telephone number.

Very truly yours,

John W. Daniels

JWD/lf

Planning

HANKIN, SANDSON & SANDMAN
COUNSELLORS AT LAW
A PROFESSIONAL CORPORATION
30 SOUTH NEW YORK AVENUE
ATLANTIC CITY, NJ 08401

STEPHEN HANKIN
Member of New Jersey
and District of Columbia Bars

MARK H. SANDSON
Member of New Jersey
and Georgia Bars

ROBERT S. SANDMAN
Certified Civil Trial Attorney
Member of the New Jersey
and Pennsylvania Bars

THOMAS F. BRADLEY
Member of the New Jersey
and Pennsylvania Bars

JOHN F. PALLADINO
Member of the New Jersey Bar

TELEPHONE NUMBER
(609) 344-5161

TELECOPY NUMBER
(609) 344-7913

September 29, 1993

Our File Number

Lt. Colonel Kenneth H. Clow
Department of the Army
Philadelphia District
Corps of Engineers
Custom House 2nd and Chestnut Streets
Philadelphia, PA 19106-2991

Dear Lieutenant Colonel Clow:

I have read with interest the New Jersey Shore Protection Study "Brigantine Inlet to Great Egg Harbor Inlet" which was the subject of a reconnaissance study report by the U.S. Army Corps of Engineers, Philadelphia District, in February of 1992.

Given the substantial changed circumstances which exist along the Longport shoreline which abuts the Great Egg Harbor Inlet, I suggest that the reconnaissance study report be revised accordingly.

Since the completion of the reconnaissance study report, the dredging project in Great Egg Harbor has been completed, following which and within a four (4) week period, the tip of Longport has lost approximately 800 linear feet of beach and a height of some 13 to 14 feet. All of this has been without the aid of any unusual tides or storms. The "mysterious" disappearance of the beach is nothing less than bizarre. Without attributing what I conceive to be the reason for this substantial loss of beach, it is important for your report to reflect what has occurred here. Enclosed you will find photocopies of pages 54 and 55 of the report. Please note the substantial amount of beach between the 11th Avenue and Point Drive terminal groins.

Without the benefit of a revised study, it seems to me that the reconnaissance study report will serve no useful purpose.

Kindly let me hear from you at your very earliest convenience.

625

Thank you very much.

Very truly yours,

STEPHEN HANKIN
SH/js
Enclosure
cc: U.S. Congressman William J. Hughes
Central Park East
Building 4, Suite 5
222 New Road
Linwood, NJ 08221

Robert L. Callegari, Chief, Planning Division
U.S. Army Corps of Engineers
Philadelphia District
Custom House 2nd and Chestnut Streets
Philadelphia, PA 19106-2991

Lynn Bocamazo, Engineer
U.S. Army Corps of Engineers
New York District
CENAN-PL-CE
26 Federal Plaza, Room 2155
New York, NY 10278-0090

Bruce Ebersole, Chief, Coastal Processes Branch
Coastal Engineering Research
Waterways Experiment Station
U.S. Army Corps of Engineers
CEWES-CR-P
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Bernard J. Moore, Administrator
Engineering and Coastal Element
Environmental Regulation Wing
New Jersey Department of
Environmental Protection and Energy
1510 Hooper Avenue
Toms River, NJ 08753

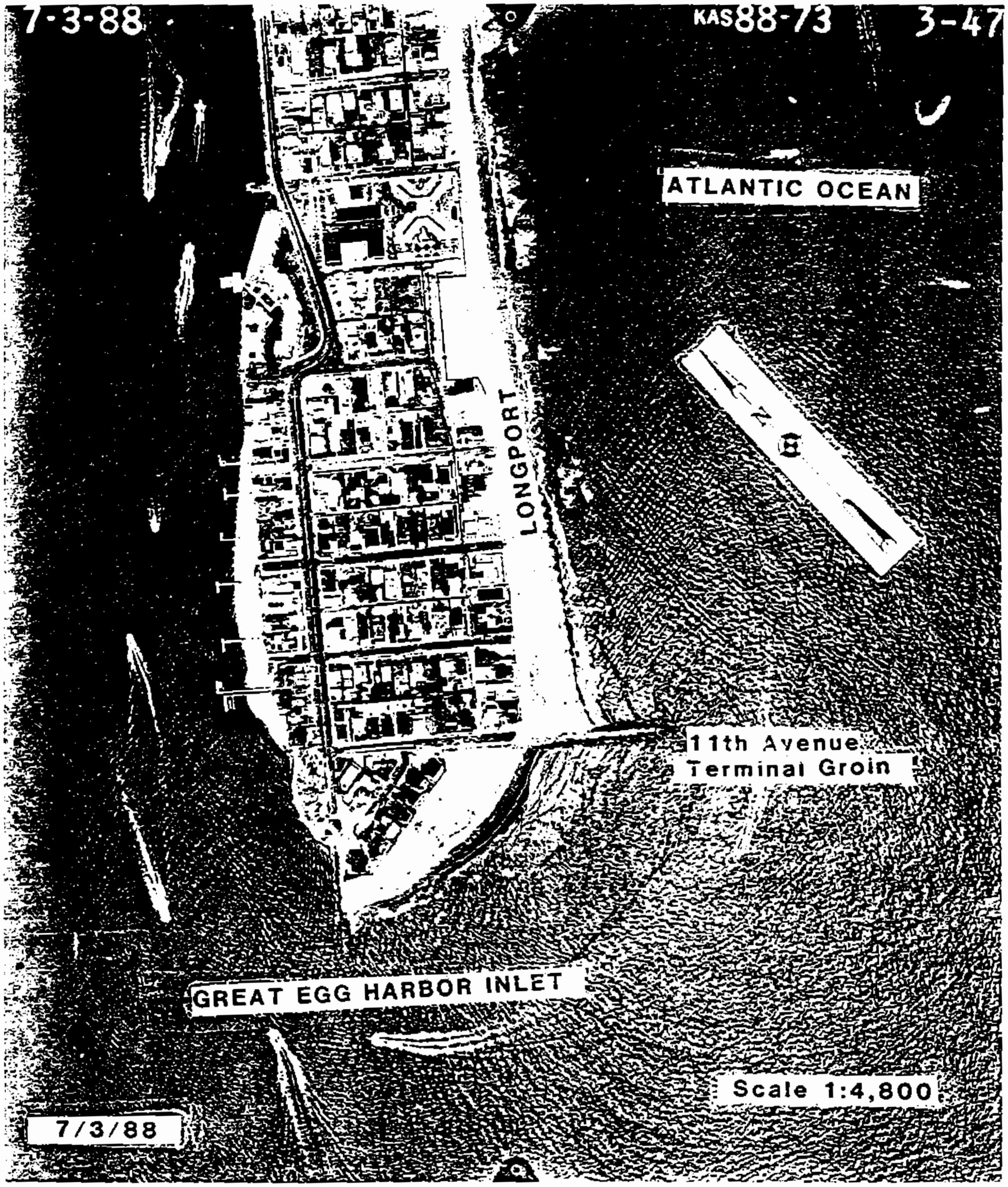


FIGURE 11. Southern end of Longport, NJ - July 1988. Note the shoreline configuration on the ocean and bay sides for comparison to Figure 12. This photograph was taken during high tide.

FIGURE 12. Southern end of Longport, NJ - November 1991, Low Tide. Note the bulkheads and lack of sand under the piers on the bay side. In comparison to Figure 11, the apparent increase in fillet width at the 11th Avenue groin may be due to 1) the 1990 beachfill, 2) ephemeral effects of the 1991 Halloween Storm or 3) low tide.

The Inquirer

Monday, September 6, 1993

ELIZABETH ROBHALER [illegible]

They used to live on the beach. But since July, Stephen Hankin and his daughter, Ashley, have found the ocean [illegible] crashing into the base of their home in Longport. Hankin blames Ocean City's beach-replenishment project across Great Egg Harbor Inlet for the erosion.

Rapid erosion leaves Longport beached

In just weeks, the community's shore vanished. Even seasoned residents are baffled. And newly vulnerable.

By William H. Sokolic
INQUIRER CORRESPONDENT

LONGPORT — Before July, Shirley Gindhart used to be able to step off the deck behind her beige two-story oceanfront home on Point Drive and onto a beach wide enough for sunbathing.

But no more.

Now if she were to step off that wooden deck, Gindhart would take a 10-foot plunge into the surf.

Gindhart and her neighbors have watched the sand in their back yards disappear into the ocean, leaving only a bulkhead as protection.

"[The disappearance] started July 4 and most of the sand was gone in four weeks," she said.

Her neighbor, Stephen Hankin, a 20-year resident of Point Drive, described the rapid loss as bizarre.

Said Longport Mayor William Fiore: "I've lived here since 1949, and the sand has come and gone in that area. But I've never seen it go like that. On July 4th we were worrying about how to keep that beach clean. We're talking a substantial amount of sand lost."

Fiore and others worry that the vanishing sand makes the palatial homes along a stretch from Point Drive to 11th Avenue vulnerable to stormy seas, especially with the storm season kicking into gear.

In last December's storm, homes here were doused and flooded even with the beach, Gindhart said. During a typical high tide these days, sprays of water shoot up from the base of the exposed bulkhead and onto the houses. Continued pounding by the waves could undermine the bulkhead, a wooden barrier between the homes and ocean, state engineers say.

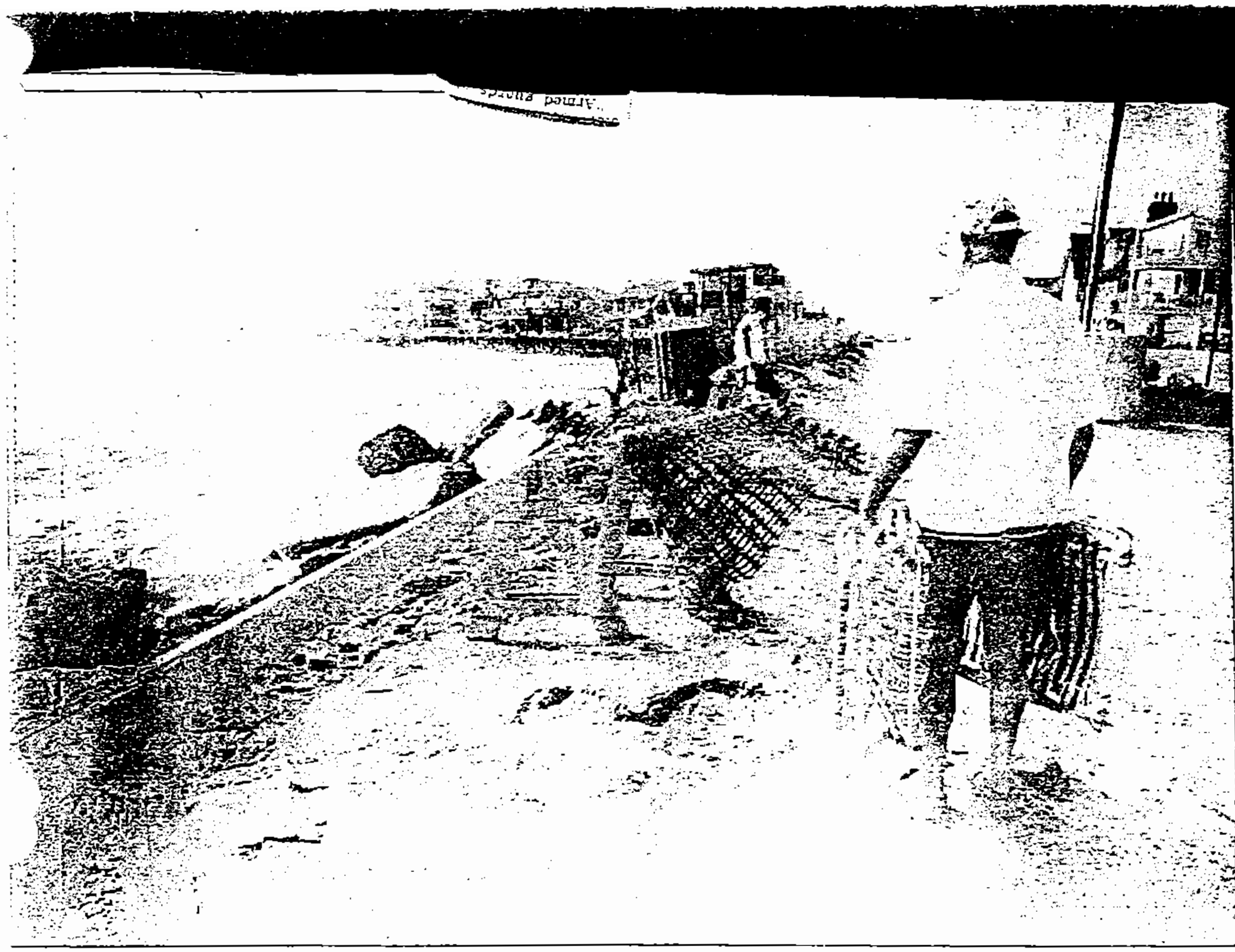
To allay those worries, the state Department of Environmental Protection and Energy has ordered emergency work to build a barrier between the bulkheads and the ocean to break the force of the waves. The emergency plan calls for the addition of a 14-foot-wide rock revetment, essentially a rock barrier, between the 11th Avenue and Atlantic Avenue groins that surround the former beach.

The reason for the rapid erosion remains a mystery, [illegible] people here have developed a theory or two. Some have gone so far as to blame Ocean City for the disappearance. Ocean City lies across the Great Egg Harbor Inlet from Longport. And Ocean City reaped a harvest of sand in the last two years thanks to a more than $30 million beach replenishment project.

"There's no question the dredge project is responsible," Hankin said. "It's due to fooling around with Mother Nature. We have to go after those responsible."

The sand for the replenishme[illegible] didn't come from Longport's [illegible] — the borough has preciou[illegible] to spare. Instead, it came from the floor of the inlet. Rumor has it among the Longport crowd that the swirling

See LONGPORT on 32



Near 11th Street, the water has overtaken vast stretches of sand, leaving beachgoers beachless and homeowners worried. Says Longport Mayor William Fiore: "I've lived here since 1949, and the sand has come and gone in that area. But I've never seen it go like that."

Rapid erosion leaves Longport beached

LONGPORT from B1

currents in the inlet were somehow altered by dredging up the sand in a location different from the one mapped out, and in the process, washed out Longport's tip.

But it's not an easy point to prove, said Kenneth Smith, a coastal consultant for Longport.

Indeed, engineers with the DEPE have all but dismissed the dredge theory. "There's no evidence to me that the dredging went outside the [prescribed] area," said Bernard Moore, chief of the state Bureau of Coastal Engineering.

Moore says a northern migration of the channel, the deepest point in the inlet, may well be the culprit behind the sand loss.

"The fast current in the new channel allowed waves to come closer to shore before breaking, and it [illegible]ed out sand," he said in support of the theory. But Moore had no ready explanation for the channel's movement to the north.

The former beach did have a tendency to come and go at whim over the years. "For quite a few years, the beach would leave in the fall and come back in the spring," Gindhart said.

But it had been around for about a decade, and folks had gotten used to it. Given Longport's history, though, it's no wonder they sounded an alarm.

Early in the century, the sea gobbled up the first 10 blocks of the borough, which explains why the southernmost street is called 11th Avenue.

And since the beach disappearance, the only thing separating 11th Avenue from the ocean is a fence, a loose collection of rocks — and the former beach.

Borough officials don't want to see any more of the town go under water.

If nothing were to be done, not only would the homes on Point Drive be threatened, but those on 11th Avenue as well, Hankin said.

The DEPE wants to add still more rocks to temporarily create another layer of protection for the surrounding streets. Reaching into the new $15 million shore-protection fund, the state has promised to pay for 75 percent of the $400,000 cost of the emergency work.

The borough must chip in the remainder. Last week, borough commissioners approved a resolution to finance their portion. But where they will get the money is another matter. Many residents oppose spending local tax money to protect a handful of posh, private homes. To do so would set a precedent for others who want similar protection, said Mary Nugent, a member of the board of the Longport Civic Association.

The borough may levy a special assessment against property owners along the affected area to pay the local share. Nugent proposed that the homeowners involved donate the money needed to the Longport Shorefront Protection Trust Fund, which would turn it over to the state.

"It comes to less than 1 percent of the value of their homes," Nugent said. "And they could take a tax write-off."

In the meantime, everyone is optimistic the sand can return just as mysteriously as it disappeared.

"Sand moves in and out all the time. Something could change, and the sand could come back almost as rapidly as it left," Moore said.

(11)

PRESS
ATLANTIC CITY, NJ
DAILY 84,211

THURSDAY
JUL 27 1995
NEW JERSEY CLIPPING SERVICE
13 AM
AEBM

Sand heaps hide ocean in A.C.

200AH

The best part of walking the Boardwalk in Atlantic City always was smelling and seeing the ocean.

My last visit there was over the Fourth of July this year. Someone has managed to make the shore line with the breaking waves disappear. Mounds of ugly sand have taken away the best part of walking the Boardwalk.

I was born and raised in Atlantic City in 1929 B.C. (before casinos). My mother and father still live there, so I get to visit four or five times a year. Riding a bike on the Boardwalk every morning is one of the highlights of my visit. Except for one small area next to the Ocean One shopping pier, someone has taken away the real view of the ocean.

I have been told that the Army Corps of Engineers has told city officials that these mounds of sand will protect our Boardwalk from being destroyed by a tropical storm or hurricane. I bet these engineers have never lived in Atlantic City and never will.

When I was a small boy and when I brought my six children to the Atlantic City shore, we played in the sand and ocean. One of our favorite games was to build a fort down near the water's edge and try and keep the rising tide from washing over our fort. Let me tell you we never won. The ocean was always the winner.

The same common-sense theory applies here. Those ugly mounds of sand will not stop the Atlantic Ocean from going where it wants to go in a large hurricane type of storm. The money being wasted (they were working on the Fourth of July) could be used to get rid of the many, many eyesores still left in the downtown area.

Sometime in the future, new blood will be guiding Atlantic City's decision-making and someone will say, "get rid of those ugly mounds of sand and give the people back the natural beauty that belongs there."

LEWIS F. BOBB
Woonsocket R.I.

WILLIAM J. HUGHES
2D DISTRICT, NEW JERSEY

COMMITTEE ON THE JUDICIARY
SUBCOMMITTEE ON INTELLECTUAL PROPERTY AND JUDICIAL ADMINISTRATION (CHAIRMAN)
COMMITTEE ON MERCHANT MARINE AND FISHERIES

Congress of the United States
House of Representatives
Washington, DC 20515-3002

WASHINGTON OFFICE:
241 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-3002
(202) 225-6572

DISTRICT OFFICES:
CENTRAL PARK EAST
BUILDING 4, SUITE 5
222 NEW ROAD
LINWOOD, NJ 08221
(609) 927-9063

151 NORTH BROADWAY
P.O. BOX 248
PENNSVILLE, NJ 08070
(609) 678-3333

October 1, 1993

Mr. Stephen Hankin, Esq.
Hankin, Sandson & Sandman
30 South New York Avenue
Atlantic City, NJ 08401

Dear Mr. Hankin:

Thank you for sending me a copy of your letter to the Army Corps of Engineers regarding the New Jersey Shore Protection Study.

In an effort to be of some assistance, I have again contacted the Corps of Engineers in your behalf. I have asked them to carefully consider your comments and suggestions and to make every reasonable effort to address your concerns.

With kindest regards,

Sincerely,

/s/

William J. Hughes
Member of Congress

WJH:jhm
cc: Lieutenant Colonel Richard Sliwoski

CENAP-PL-PC
[illegible] OCTOBER 1993
am/6574
GAFFNEY

[illegible]

TUNNELL

BURNES

CALLEGARI

HESSMAN

[illegible]SKI

Planning Division

Stephen Hankin
Hankin, Sandson & Sandman
30 South New York Avenue
Atlantic City, New Jersey 08401

Dear Mr. Hankin:

This is in response to your letter dated September [illegible] regarding the loss of beach at the southern end of Longport.

As you accurately point out, the Brigantine Inlet to Great Egg Harbor Inlet Reconnaissance was completed in February, 1991. The Reconnaissance Report represents findings of the Corps of Engineers as of that date, for the purposes of determining whether Federal interest in shore protection exists for the study area. The results were positive and therefore the study has progressed into the feasibility phase.

The Borough of Longport is included in the Feasibility Study which began in March 1993. This study is cost shared with the New Jersey Department of Environmental Protection and Energy. Appropriate data are being collected during this phase of study in an effort to better understand the natural forces which are responsible for sand transport along Absecon Island.

As part of the normal conduct of this study, my staff routinely contacts municipal officials and makes site visits to ascertain the problems as they exist in any study area. We are fully aware of the recent loss of sand at the southern end of Longport, the State's ongoing remedial measures, as well as the dynamic historical nature of the barrier islands along the coast of New Jersey. During the course of the study, all relevant information will be assessed to develop an effective shore protection project for Longport and Absecon Island.

I hope this information is satisfactory for your needs. Should you have additional questions, please do not hesitate to contact me.

Sincerely,

R. F. Sliwoski, P.E.
Lieutenant Colonel, Corps of Engineers
District Engineer

State of New Jersey
Department of Environmental Protection and Energy
Division of Science and Research
CN 409
Trenton, NJ 08625-0409
Tel. # 609-984-6070
Fax. # 609-292-7340

Jeanne M. Fox
Acting Commissioner

Robert K. Tucker, Ph.D.
Director

January 19, 1994

Mr. Robert L. Callegari
Department of the Army
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3391

Dear Mr. Callegari,

Based on the digital Data Distribution Agreement of 9/7/93 the Office of Information Resources Management, NJDEPE, is pleased to assist the Corps of Engineers with the Brigantine Inlet to Great Egg Harbor Inlet feasibility study. Enclosed you will find a QIC150 tape with ARC/INFO EXPORT files that you have requested written using the UNIX TAR command. Data documentation in hard copy and/or digital form is also enclosed.

Not all the coverages requested are available for the study area in Atlantic County. On your list, numbers 9,11,12,13,17,19,20 and 22 are not yet available. The integrated terrain unit for Atlantic County including land use/land cover, soils, USGS floodprone areas, and geology should be completed by April. In addition, the Upper Wetlands Boundary for quad 157 is not available yet. The other data layers are either not funded or have no set time for their completion. Please get back in touch with this Office in several months concerning these data layers.

We are interesting in receiving notification of when the project is completed and a list of the digital data layers produced as part of the project. Should you have any questions concerning these issues or the data, please give me a call (609) 633-8144.

Sincerely,

Lawrence L. Thornton
Research Scientist

enclosures
c:Bernard J. Moore, NJDEPE
Doug Gaffney, COE

634

HANKIN, SANDSON & SANDMAN
COUNSELLORS AT LAW
A PROFESSIONAL CORPORATION
30 SOUTH NEW YORK AVENUE
ATLANTIC CITY, NJ 08401

STEPHEN HANKIN
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Member of the New Jersey Bar

TELEPHONE NUMBER
(609) 344-5161

TELECOPY NUMBER
(609) 344-7913

September 6, 1993

SEP 07 1994

Our File Number

Lt. Colonel Kenneth H. Clow
Department of the Army
Philadelphia District
Corps of Engineers
Custom House 2nd and Chestnut Streets
Philadelphia, PA 19106-2991

RE: Longport Shoreline - Great Egg Harbor Bay Inlet - Dredging Project

Dear Lieutenant Colonel Clow:

I last wrote you almost a year ago respecting the above-captioned matter and the then completed dredging project.

We have recently received word that the Corp will soon begin dredging again which we find highly objectionable, given what is a universal conclusion regarding the complete loss of beach at the southern end of Longport due to the dredging that was completed last year. While we were fortunate enough to receive a small rock revetment, the condition at the Southern tip of Longport is nonetheless disastrous. We would indeed be less than remiss if we did not object to the project going forward absent some modification to permit some sand to be diverted to Longport. We are undergoing a treacherous situation here even on mild days. Human life and property are in serious jeopardy and we cannot allow this project to make matters worse.

Please let me hear from you at your very earliest convenience.

Thank you.

Very truly yours,

STEPHEN HANKIN
SH/js
Enclosure
cc: See Attached Service List

WILLIAM J. HUGHES
2D DISTRICT, NEW JERSEY

COMMITTEE ON THE JUDICIARY
SUBCOMMITTEE ON INTELLECTUAL PROPERTY AND JUDICIAL ADMINISTRATION (CHAIRMAN)
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DISTRICT OFFICES:
CENTRAL PARK EAST
BUILDING 4, SUITE 5
222 NEW ROAD
LINWOOD, NJ 08221
(609) 927-9063

151 NORTH BROADWAY
P.O. BOX 248
PENNSVILLE, NJ 08070
(609) 678-3333

September 9, 1994

Colonel Richard F. Sliwoski
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Dear Colonel Sliwoski:

I recently received additional correspondence from my constituent, Mr. Stephen Hankin, regarding dredging in the Great Egg Harbor Inlet.

Mr. Hankin continues to insist that previous dredging at the mouth of the Great Egg Harbor Inlet, in connection with the Ocean City beach nourishment project, is the cause of erosion at the southern tip of the community of Longport.

Now that the Corps is considering additional dredging in that area, Mr. Hankin has taken the position that the Corps should take steps to insure that Longport's problems are reviewed.

I would appreciate it if the Corps of Engineers would consider Mr. Hankin's correspondence and provide any information or assistance that is available to respond to his concerns.

With kindest regards,

Sincerely,

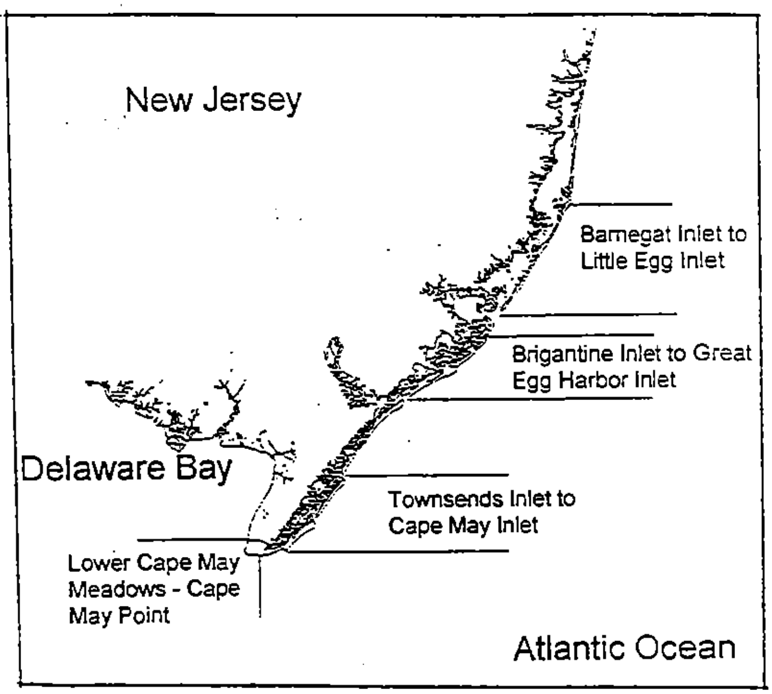
William J. Hughes
Member of Congress

WJH:jhm
Enclosure

NEW JERSEY
SHORE PROTECTION STUDY
U P D A T E

US Army Corps of Engineers
Philadelphia District

JUNE 1994 INFORMATION BULLETIN NUMBER 5



Areas of ongoing studies.

STUDY UPDATE

The New Jersey Shore Protection Study was initiated in 1989 in response to water quality concerns, beach erosion and storm damage along the coast. The Limited Reconnaissance Study included the entire New Jersey coast from Sandy Hook to Cape May. The study was completed in September 1990, and recommended six specific areas of the New Jersey coast for further study. Four of the six areas are currently under study.

The Townsends Inlet to Cape May Inlet Reconnaissance Study was completed in January 1992, and the Brigantine Inlet to Great Egg Harbor Inlet Reconnaissance Study was completed in February 1992. Both studies have progressed into the Feasibility Phase of the Corps' Civil Works planning study process, cost-shared with the New Jersey Department of Environmental Protection and Energy (NJDEPE) as the non-federal sponsor. Reconnaissance studies were initiated for Lower Cape May Meadows in March 1993, and for Barnegat Inlet to Little Egg Inlet (Long Beach Island) in March 1994. Cape May Point was added to the Cape May Meadows study in October 1993.

Townsends Inlet to Cape May Inlet

The Townsends Inlet to Cape May Inlet Feasibility Study began in December 1992. Shore protection measures will be examined along the ocean fronts of Avalon and Stone Harbor, as well as the inlet frontages of Avalon and North Wildwood. The southern end of Stone Harbor near Hereford Inlet is an undeveloped wildlife conservation area which serves as an important stopover location for migratory shorebirds and birds of prey, as well as a buffer against storm waves. This area is rapidly eroding, especially behind the terminal groin and revetment. The Feasibility Study is investigating the possible causes for the erosion of this valuable habitat, the impact on the surrounding community, and potential solutions.

Brigantine Inlet to Great Egg Harbor Inlet

The Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study began in March 1993. Shore protection measures will be examined for the Brigantine oceanfront, the Absecon Inlet frontage of Atlantic City, and the oceanfront of Absecon Island. The study is being conducted in two stages. The first stage is the Absecon Island Interim Study, which is currently underway. This stage includes ongoing data collection efforts to analyze coastal processes along the entire study area.

The second stage is the Brigantine Island Interim Study which will result in the final feasibility report.

Both Feasibility Studies are being cost shared 50%-50% between the Federal government and the NJDEPE. All interested parties are encouraged to be actively involved during the Feasibility Phase because it is during this phase that a specific shore protection plan begins to take shape.

Lower Cape May Meadows-Cape May Point

The Lower Cape May Meadows Reconnaissance Study began in March 1993. Lower Cape May Meadows comprises 350 acres of undeveloped oceanfront land which includes Cape May State Park and the Cape May Migratory Bird Refuge owned by the Nature Conservancy. Both of these areas contain unique freshwater wetlands. The Meadows is home for threatened and endangered birds such as the piping plover. Vast numbers of migratory birds such as American bald eagles, peregrine falcons, osprey and other raptors use the area to rest and feed as they travel along the North Atlantic Flyway. However, this vital habitat, which is one of the most visited avian viewing areas on the East Coast, is threatened by erosion.

The natural transport of sand along the coast of New Jersey has been altered over the years by development. One aspect of this development is the use of inlets for commercial and recreational navigation.

Birdwatchers at Cape May Point State Park.

At Cape May Inlet in 1911, jetties were built to stabilize the navigation channel. The purpose of the Cape May Inlet jetties is to prevent sand from entering the inlet, but they also hinder sand from reaching Lower Cape May Meadows. This makes the effects of gradual erosion processes more pronounced, and increases the area's susceptibility to storm damage. In addition, saltwater from the ocean enters the freshwater wetlands during storms, severely altering the habitat. The Reconnaissance Study will investigate environmental protection measures and the effects the Cape May Inlet jetties may have had on Lower Cape May Meadows.

In response to the concerns of Congress, the Lower Cape May Meadows Reconnaissance Study was expanded in October 1993 to include the Borough of Cape May Point. Cape May Point is a residential community with approximately one mile of shorefront. Here, the Delaware Bay meets the Atlantic Ocean, producing complex wave and current interactions. Continuous erosion at Cape May Point has prompted the repeated construction of various shore protection projects over the years. The most recent projects included the nine existing groins built in the 1960's, and small scale beachfills placed after the recent storms. Even with these projects, Cape May Point is still subject to beach erosion and storm damage. The Reconnaissance Study will investigate hurricane and storm damage reduction measures for this area.

Barnegat Inlet to Little Egg Inlet (Long Beach Island)

The Barnegat Inlet to Little Egg Inlet Reconnaissance Study began in March 1994. The study area extends approximately 20 miles along Long Beach Island and includes the communities of: Barnegat Light, Harvey Cedars, Surf City, Ship Bottom, Beach Haven and Long Beach Township. Like many barrier islands, erosion over the years has narrowed most of the beaches of Long Beach Island, reducing the storm protection to communities provided by the beach and dunes.

Protection of the barrier island will also help protect environmentally sensitive areas inland. To the west of Long Beach Island are Barnegat Bay and Little Egg Harbor, which are two of the largest bays along the New Jersey Coast. Both are abundant sources of fish and shellfish, providing recreation and commerce for the area as well as habitat for a variety of species of fish and wildlife, both migratory and native. The presence of a stable barrier island will prevent breaches, such as those which occurred at Harvey Cedars during the December 1992 storm. Such events can alter water salinity in the back bay. Investigating water quality and coastal pollution problems are objectives of the overall New Jersey Shore Protection Study.

DATA COLLECTION

A thorough understanding of coastal processes is needed to improve the implementation of shore protection projects. Coastal processes include such topics as sand transport, breaking wave dynamics, and wave/current interaction in the vicinity of coastal inlets. Data collection efforts are underway to gain a better understanding of the coastal processes of Townsends, Hereford and Absecon Inlets, and their impacts on adjacent shorelines.

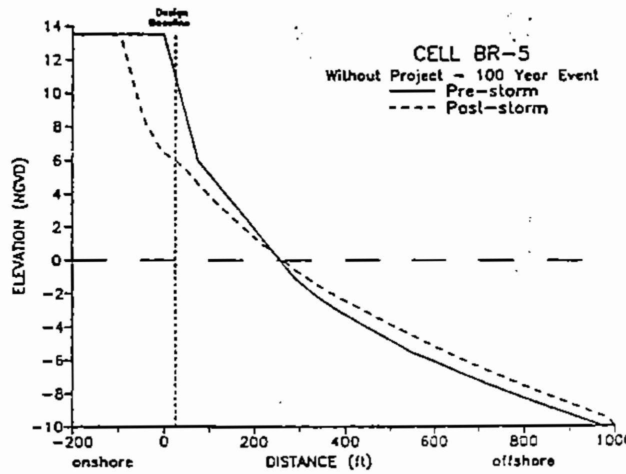
Beach and Hydrographic Surveys

Most beaches experience a seasonal cycle of erosion and accretion. Storms in the winter remove sand and deposit it temporarily in offshore bars in shallow water. During the summer months, waves return sand from the bars to the beach. However, major storms, such as the Northeaster of December 1992, can cause a permanent loss of sand. Strong storm waves can take sand from the beach and deposit it at depths of over 20 feet. Lower velocity waves on a calm day are not strong enough to suspend the sand and return it to the beach. As a result, storms such as northeasters can remove large quantities of sand from the natural ocean transport system.

December 1992 Storm - Brant Beach.

Beach and hydrographic data are used to study beach changes. Surveyors use standard techniques to survey the beach at specific locations. Hydrographic surveys take place in the nearshore zone, the area of shallow water extending from the shoreline to where the waves break. Usually, a boat uses an acoustic sounder to measure water depth. The data collected from beach and hydrographic surveys is used to produce a profile image of the beach from the dune line through the nearshore zone.

Beach surveys along Absecon Island, Seven Mile Beach, Five Mile Beach and Lower Cape May Meadows were completed during the summer and winter of 1993. Brigantine Island beach surveys were completed this spring. Hydrographic surveys have been completed for Lower Cape May Meadows in September and Absecon Island in December. Hydrographic surveys of Townsends, Hereford, and Absecon Inlets were conducted during the winter. Results of these surveys will be used to map the location and depth of the channels.



Example of beach profile.

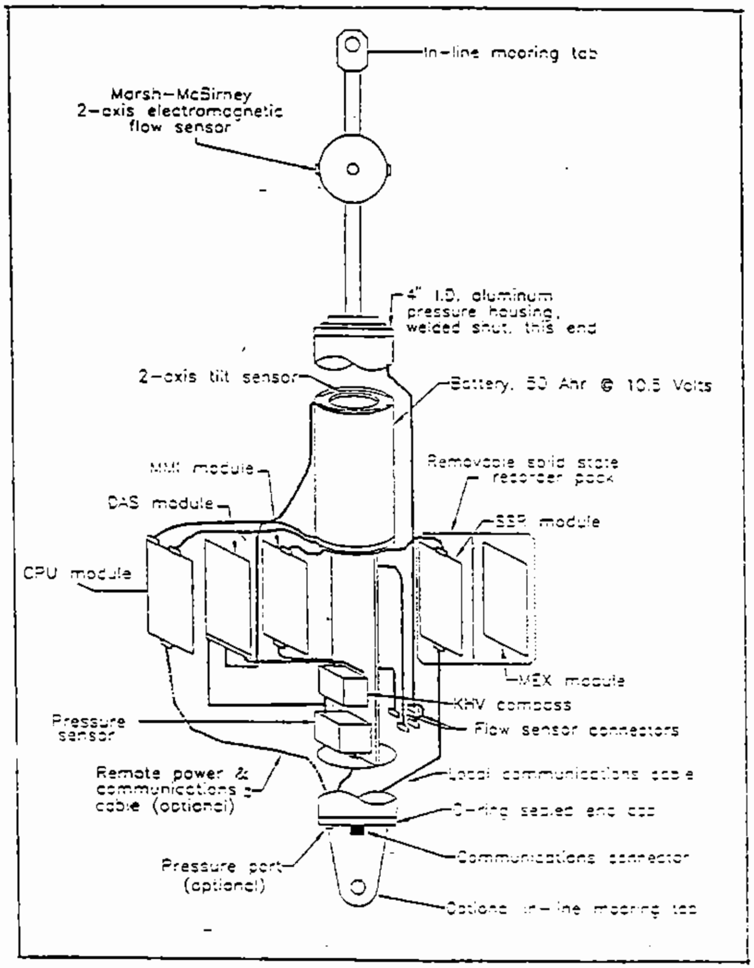
In addition to the survey data, samples of beach material were taken along selected profile lines when the surveys were performed. These samples are analyzed to characterize the beach by grain size and composition. This information will help the Corps to find compatible beach material for specific locations, if beachfill material is required.

Sampling of offshore sand deposits was completed in October. These samples are being analyzed for grain size and composition. This information will be compared to the results of the beach sample analyses and acoustic sub-bottom profiling to determine the most suitable source(s) of beachfill material. Once identified, these borrow areas may be valuable resources to various agencies after a major storm.

Avalon '93 Project

During the summer of 1993, the Borough of Avalon implemented a shore protection project of its own to test some experimental methods of sand retention. The project included the placement of sand-filled textile tubing along the inlet frontage and a 150,000 cubic yard beachfill along the oceanfront between the 8th Street jetty and 17th Street. In addition, an artificial reef about 1,000 feet long was placed offshore between the 8th Street jetty and 11th Street prior to the beachfill. The reef is composed of interlocking hollow concrete sections. The purpose of the reef is to dissipate some of the incoming wave energy and prevent outgoing currents from carrying sand to deeper water.

The Stevens Institute of Technology (SIT) tested the reef design before it was installed. SIT will be monitoring the performance of the reef over the next two years by obtaining field data every three months and after major storms. Stockton State College will be obtaining beach profiles of the area. In addition, data collected by the ongoing Townsends Inlet to Cape May Inlet Study will also be used to help monitor the project.



PUV (Pressure, U-V Direction) wave gauge.

<u>Wave, Tide and Current Data</u>

Wave gauges were installed near Avalon in June and near Atlantic City in October of 1993. They were deployed by boat in depths varying from 10 to 42 feet. The gauges are the PUV type which record changes in pressure and direction of flow along two axis. Water pressure relates to wave height. The data is collected in twenty minute durations every three hours. The data will be retrieved by a diver every two months. After analysis, this data will provide a directional wave spectrum along with tidal elevation and ambient current speed and direction. The current spectrum will be decomposed to provide tidal and wave driven currents.

Tide gauges have been installed in the back bay channels. Supplemental current data is being collected in the inlets using acoustic doppler current profiler technology.

This information and the survey data will be used as input for numerical models which will simulate various coastal processes such as wave transformation, storm damage, ebb and flood flow during tides and shoreline changes.

All of the data collection and cooperative efforts discussed above, will provide valuable quantitative coastal information. This data will be helpful for our existing study areas as well as other locations along the New Jersey coast which experience severe erosion and storm damage.

Mapping & Photogrammetry

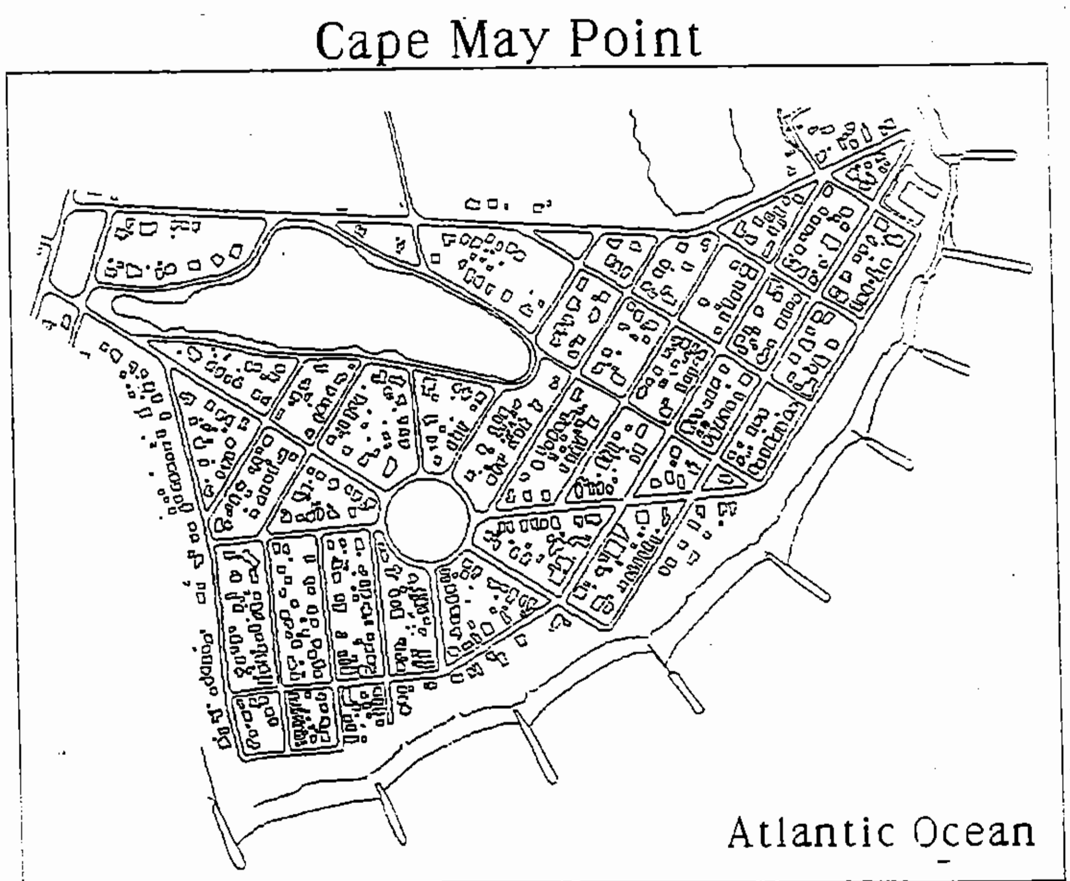
Aerial photographs of the study areas taken in March and October of 1993 are being combined with the beach and hydrographic survey data to develop digital orthophotographs. Orthophotographs form the basis of the Geographic Information System (GIS) because they are referenced to a mapping datum. All data collected during these studies is also referenced to the same datum which is the New Jersey State Plane Coordinate System, North American Datum 1983.

The GIS can accurately depict beachfront structures, many public works features, and elevations. The GIS will also include geotechnical and other types of data obtained during the course of the New Jersey Shore Protection Study.

In addition, the Philadelphia District has entered into a Data Sharing Agreement with the NJDEPE. The NJDEPE is providing maps in digital format for Cape May and Atlantic Counties for use in the studies. These maps represent: areas of dredging and dredge material disposal, tidal wetlands, bird and shellfish habitats, and hydrology. In return, the District will be able to update NJDEPE shoreline change maps, and provide Digital Terrain Models (DTM's) of shore communities. The use of this information within the GIS will allow the Corps to more effectively monitor shoreline changes, storm damage, and to identify areas in New Jersey which are vulnerable to flooding during storms.

COMMENTS

We appreciate your involvement and suggestions in these ongoing studies. Your concerns and ideas are helpful to us, and will become even more important as we move into the planning and development of specific coastal projects. Please address your comments to the Philadelphia District at our address on the attached Comment Form.



An example of the Corps' New Jersey GIS.

COMMENT FORM

If you have any comments on the New Jersey Shore Protection Study, or corrections, additions, or deletions for our mailing list, please cut along the dotted line and mail the completed form to:

U.S. Army Engineer District, Philadelphia
ATTN:CENAP-PL-PC
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

- -

______ Yes. Please correct or add my address to the New Jersey Shore Protection Study mailing list.

______ No. Please delete my name from the mailing list.

NAME: ____

ADDRESS: ____
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COMMENTS:

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U. S. Army Engineer District
Philadelphia
Attn: CENAP-PL-PC
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

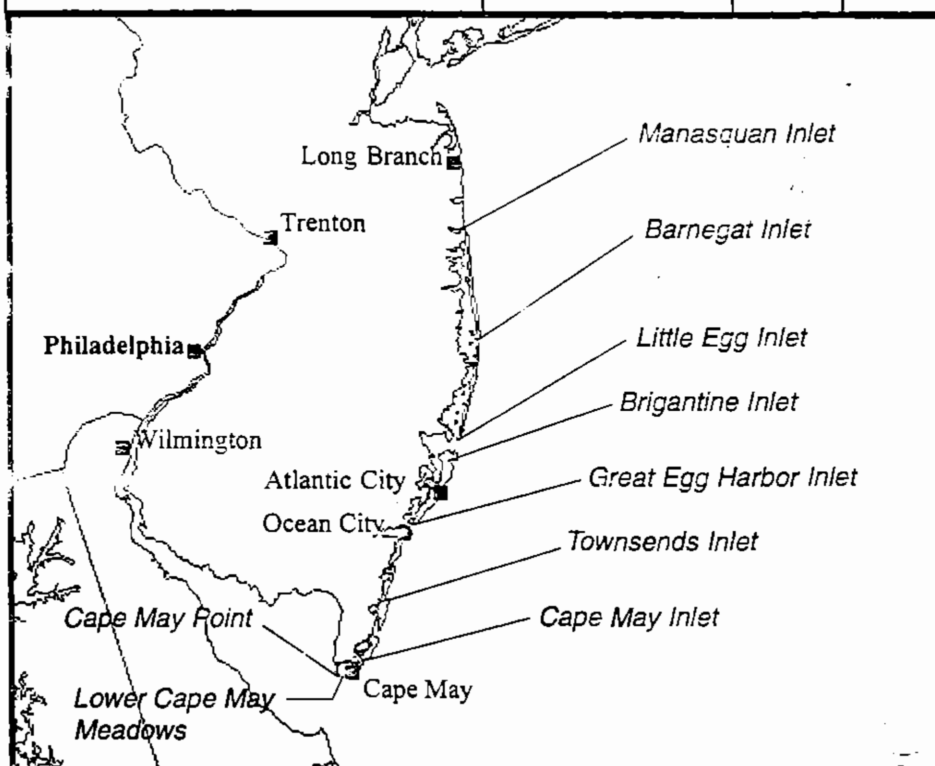
September 1995

US Army Corps of Engineers
Philadelphia District

New Jersey Shore Protection Study UPDATE

Editor's Note: Starting with this issue of the Update, you can expect to hear from us semiannually. Our purpose is to keep you informed on the status of each study area, while also reporting on topics of general interest to our partners in shore protection.

Project Name	Current Phase	Start	Finish
Manasquan Inlet to Barnegat Inlet	Reconnaissance	Mar-95	Mar-96
Barnegat Inlet to Little Egg Inlet	Hold (recon complete)	Mar-94	Mar-95
Brigantine Inlet to Great Egg Harbor Inlet	Feasibility		
• Absecon Island Interim Study		Mar-93	Dec-96
• Brigantine Island Interim Study		Sep-95	Nov-98
Great Egg Harbor Inlet to Townsends Inlet	Reconnaissance	Apr-95	Apr-96
Townsends Inlet to Cape May Inlet	Feasibility	Dec-92	Jul-96
Lower Cape May Meadows – Cape May Point	Feasibility	Apr-95	Aug-98



New Jersey Shore Protection Study Area

About this study

The U.S. Army Corps of Engineers initiated the New Jersey Shore Protection Study in 1989 to address beach erosion, water quality, and storm damage along the coast.

The initial Limited Reconnaissance Study, completed in September 1990, recommended six areas between Manasquan Inlet and Cape May for further study.

All six studies are now underway, with the New Jersey Department of Environmental Protection (NJDEP) as local sponsor. Three are in the Feasibility phase, two in the Reconnaissance phase, and one on hold (see **"The Future of Shore Protection," page 4**).

About Corps projects

Unlike grant agencies, Corps of Engineers funding is 100 percent project-based. Every project follows a three-phase process, with each phase justified and funded on its own merits.

Reconnaissance

The reconnaissance phase is initiated in response to a local water resource problem. Funding for this preliminary phase is 100 percent Federal.

Corps planners carry out these activities over 12 months:

- Identify coastal erosion and water quality problems attributed to both natural and manmade causes
- Collect data on homes and other buildings, public infrastructure, and existing protective structures for storm modeling
- Use benefit-cost analysis to decide whether the Federal government should develop more detailed plans to address these problems
- Lay out the Feasibility Study and identify local sponsor(s) for non-Federal share of the cost

Feasibility

The Feasibility Study is where a specific shore protection plan takes shape. A non-Federal sponsor shares 50 percent of the costs. This detailed investigation usually lasts 3 to 5 years.

Working closely with other Federal, state and local authorities, the District spends much of this time complying with laws and policies and making sure no regulatory matters are overlooked. As a result of this phase, a report is processed to Congress for authorization of a project. These are some of the major tasks:

- Collect data on waves, tides, currents, movement of sand, and sand composition
- Construct predictive hydrodynamic models and refine storm models
- Determine water and sand circulation in the vicinity of the inlets
- Prepare shore protection designs which maximize national economic benefits
- Prepare Environmental Impact Statement (EIS) or Environmental Assessment (EA)

Design and construction

Under mostly Federal funding (traditionally 65/35), the District completes detailed preconstruction engineering and design, including construction plans and specifications. Private firms are then contracted to build a shore protection project based on the final Feasibility Study report.

Individual studies

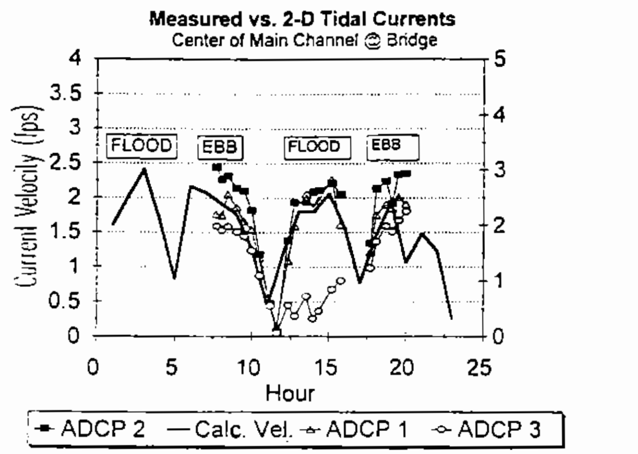
Manasquan Inlet to Barnegat Inlet

The Reconnaissance Study is focusing its modelling efforts on the "target" communities of Mantoloking, Lavallette, and Seaside Heights. Each of these maintains natural and manmade characteristics similar to those found elsewhere within the study area, and will be treated accordingly.

Philadelphia District will be looking at many issues in the course of its investigations. Here are two:

1. Public access. Localities with private beaches, insufficient parking, and/or limited beach access must ensure public access to be eligible for Federal funds.
2. Sand sources. Ocean floor contours drop sharply along this part of New Jersey, making it harder to find enough sand for replenishment.

Example of verifying current measurements with models



This study also includes Island Beach State Park, one of the last relatively undisturbed barrier islands within New Jersey. Its sand dunes, marshes, and associated wildlife are a "living laboratory" for marine biologists and other researchers. Keeping the integrity of this park will be one of the District's top priorities.

Barnegat Inlet to Little Egg Inlet

The Reconnaissance Study, which covers Long Beach Island, was just completed in March 1995. If funded, the Feasibility Study will explore erosion and storm damage solutions throughout this area. Loveladies, Harvey Cedars, Brant Beach, and Beach Haven were identified among the more vulnerable communities.

The study also identified a potential breach in the Holgate unit of Edwin B. Forsythe National Wildlife Refuge. As it might not regenerate as readily, this would cause major ecosystem degradation. The Feasibility Study will look into effective protection and/or restoration measures.

Brigantine Inlet to Great Egg Harbor Inlet

The Reconnaissance Study identified specific vulnerable sites such as the inlet frontage of Atlantic City and the oceanfronts of Brigantine, Atlantic City, Ventnor, Margate, and Longport.

The District is conducting the Feasibility Study in two stages, split geographically at Absecon Inlet. The Absecon Island draft feasibility report is due out this December, shortly after the Brigantine Island Interim Study begins (September 1995).

This report will include the results of plan formulation studies that compared the costs and benefits of many different shore protection alternatives. The one plan that maximizes net economic benefits without degrading the environment will be chosen as the National Economic Development (NED) plan. Publication of the draft report will then initiate a lengthy review process that includes public comment.

Great Egg Harbor Inlet to Townsends Inlet

The primary problems along this 16-mile coastline stem from severe beach erosion and a resulting loss of protection. Storms of moderate intensity during the winters of 1991-1993 caused considerable damage, testifying to the potential devastation of a major event.

Areas of concern include Ocean City (south of the existing Federal project), Strathmere, and Sea Isle City. Conditions at the south end of Ocean City have changed dramatically since prior Corps studies in the late 1980's.

The biggest factor has been loss of dunes since the major storms of 1991-92. At Sea Isle, erosion at the south end threatens to eventually undermine residential structures.

Townsends Inlet to Cape May Inlet

Shore protection alternatives are being evaluated along the ocean fronts of Avalon and Stone Harbor and the inlet frontages of Avalon and North Wildwood. The draft feasibility report is due out next summer (July 1996).

The southern end of Stone Harbor, near Hereford Inlet, is an undeveloped wildlife conservation area which has been eroding rapidly. It is an important stopover location for migratory shorebirds and birds of prey, and a key nesting area for herons. Erosion is most pronounced behind the terminal groin perpendicular to the beach, and along the revetment protecting the shoreline.

The District is investigating the following:

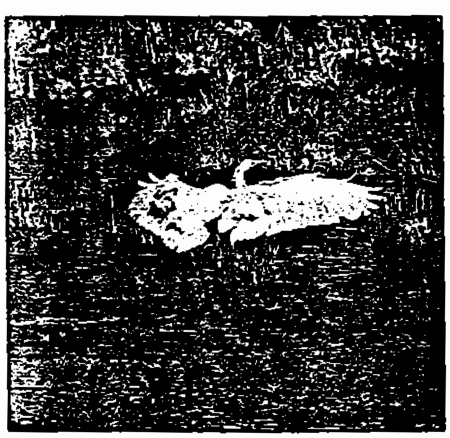
- Possible causes for the erosion of this valuable habitat
- Impact on the surrounding community
- Environmentally sensitive solutions (in coordination with NJDEP and the U.S. Fish and Wildlife Service)

Lower Cape May Meadows – Cape May Point

As Philadelphia District's first environmental restoration project, Lower Cape May Meadows represents a new concept: obtaining approval for the Feasibility phase based mainly on "environmental quality" benefits. This Feasibility Study is now moving forward with strong support from the White House.

Lower Cape May Meadows comprises 350 acres of undeveloped oceanfront land between Cape May and Cape May Point. It includes Cape May Point State Park and the Cape May Migratory Bird Refuge (owned by the Nature Conservancy), both of which contain unique freshwater wetlands.

This is one of North America's most important migratory stopovers for raptors, shorebirds, songbirds, and waterfowl. American bald eagles, peregrine falcons, and osprey are among the many species that rest and feed here along the North Atlantic Flyway.



The Meadows is also home to threatened and endangered birds such as the piping plover. Long popular among East Coast birdwatchers, it is listed as one of the nation's "Top Ten Birding Spots" in *Nature Conservancy* magazine's May/June 1995 issue. Erosion and overtopping during storms continue to seriously threaten this vital habitat.

During the Reconnaissance phase, District planners had focused on "holding the line" against further erosion. They are now exploring more ambitious options:

- Extending shoreline seaward through beach replenishment
- Restoring interior wetlands
- Managing water levels in selected areas

The close partnership that has developed between the District, the State Park, and the Nature Conservancy has clearly paid off in more thorough and innovative planning.

Along with the natural area, Philadelphia District will be looking into ways to reduce the flooding and storm damage problems at Cape May Point. Due to its proximity to Lower Cape May Meadows, just to the east, storm events that overtop or breach the Meadows dunes invariably cause flooding in the town's low lying areas. The good news is that any effective solution for the Meadows will also help Cape May Point.

For those who may be wondering, the existing Cape May beachfill project offers few side benefits for Cape May Point. Local shoreline geometry and offshore depths merely divert sand to the ocean, preventing appreciable "natural" nourishment of downdrift beaches.

Local cooperation needed on real estate

As shore protection plans unfold during the Feasibility phase, local sponsors can and should start addressing financing and real estate issues. These mostly administrative items often become "loose ends" that delay the onset of project construction.

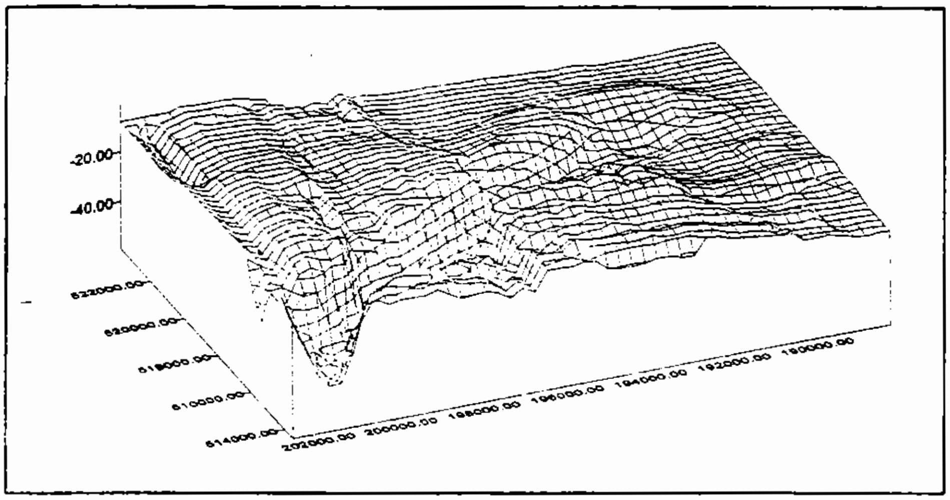
Bear in mind that real estate acquisition (and all associated costs) is the full responsibility of the non-Federal sponsor, which in this case is the State of New Jersey. It is then up to the state to work out further arrangements with local municipalities. Here is a brief overview of the acquisition process:

1. *Project Cooperation Agreement (PCA).* This legally binding document identifies the non-Federal Sponsor and explains the obligation of both parties for project construction. Under terms of the PCA, the Sponsor is responsible for acquiring all lands, easements, and rights-of-way required for the project. Public access to the beachfront area, with adequate parking, is a requirement for shore protection projects.
2. *State Aid Agreement.* The Sponsor signs an agreement with local municipalities which, in most cases, requires the municipality to acquire the necessary real estate.
3. *Final Right-of-Way Drawings.* The Corps of Engineers will forward to the Sponsor final right-of-way drawings showing real estate to be acquired. A permanent easement is usually required for shore protection.
4. The Sponsor (or municipality) must then do the following:

- *Appraisals.* Arrange for appraisal of each property (if any) to be acquired. The Corps will review the appraiser's qualifications and all actual appraisals.
- *Surveys.* Arrange for any required surveys of property to be acquired.
- *Title Evidence.* Order title evidence for each property to be acquired.
- *Acquisition.* Acquire the property. Always offer fair market value to property owners. Most acquisitions can be concluded through direct purchase.

5. *Certification.* Once all property has been acquired, the Sponsor will send evidence of public ownership to the Corps for review and certification.

Municipalities that start real estate planning at the Feasibility stage greatly improve the chances of a smooth transition to design and construction.



3-D bathymetric profile of underwater elevations

Under current administration policy, the Corps will complete any project phase (reconnaissance, feasibility, design or construction) already underway, but proceed no further. In other words, they will finish what they started. For instance, Ocean City beachfill work is already well underway and is thus far unaffected.

The first impact of this policy change was at Long Beach Island, where Philadelphia District completed its Reconnaissance Study in March 1995. Despite positive study recommendations, the Feasibility phase is on hold for now. The only study area exempt from the new policy is Lower Cape May Meadows – Cape May Point, as environmental restoration is still considered within the redefined national interest.

This issue will ultimately be settled in Washington, D.C. The debate is mainly economic: Is restoration of beaches and other coastal areas a good investment for the nation? Here are some key statistics:

- New Jersey beaches support a $7 billion tourism industry and approximately 350,000 jobs
- 25 percent of the U.S. population lives within 300 miles (an easy weekend trip) of these beaches
- Existing shore protection projects prevented about $20 million in damages at Ocean City and $9 million at Cape May during the most recent major storm (December 1992)

Where GIS fits in

While real estate acquisition is a non-Federal responsibility, the Philadelphia District can offer invaluable technical assistance. One way they can help is with precise mapping and identification of property.

The powerful planning tool known as GIS (Geographic Information System) combines computerized mapping and database technologies. It is excellent for keeping track of real estate ownership and land boundaries (known as "cadastral mapping").

Philadelphia District, along with the State of New Jersey and some municipalities, uses GIS extensively for its shore protection projects. Within the site-specific GIS, District planners can run queries, analyze data, and use real estate information to help design the project.

Inputs processed by GIS include the following:

- Aerial photos (georeferenced to the earth to create a scale map)
- Topographic (land) and bathymetric (underwater) elevation measurements
- Infrastructure statistics
- Tax data (lots, easements)
- Land classification (beaches, mud flats, wetlands, developed areas)

All this is fed into the GIS database and linked to map locations. As a result, any one feature represents not just a place name or set of coordinates, but a wealth of related information. GIS is faster, more accurate, and far more versatile than conventional methods.

The Philadelphia District routinely shares GIS data with state and local partners, and also helps the supporting Real Estate office in Baltimore maintain its cadastral (property) maps. While this information can be made available upon request by local municipalities, it is only as accurate as the data they originally supplied.

The future of shore protection

The Clinton Administration has proposed that the Corps of Engineers no longer be involved in shore protection. But for now this involves only executive policy, not Federal law. It affects portions of the New Jersey Shore Protection Study immediately, but no decisions are final.

CENAP-PL-E

DEC 0 4 1995

SWANDA
mls/6556
30 Nov 95

PASQUALE

BURNES

CALLEGARI

Environmental Resources Branch

Ms. Dorothy P. Guzzo, Administrator
New Jersey Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, New Jersey 08625

Dear Ms. Guzzo:

The U.S. Army Corps of Engineers, Philadelphia District, has recently completed cultural resources investigations on Absecon Island, Atlantic County, New Jersey as part of the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study. The first investigation, entitled A Phase 1 Submerged and Shoreline Cultural Resources Investigation, Absecon Island, Atlantic County, New Jersey (Cox and Hunter, March 1995), involved underwater remote sensing survey of two potential sand borrow areas and a tidal zone shoreline survey.

Remote sensing survey identified seven high probability targets within Borrow Area 1. Two potentially significant historic resources, the Steeplechase Pier and the Garden Pier, are located within the shoreline project area. No archaeological cultural resources were observed along the shoreline. No anomalies exhibiting shipwreck characteristics were identified in Borrow Area 2.

Subsequent investigations conducted in October, 1995 involved additional remote sensing within Borrow Area 1, remote sensing within the Longport Borrow Area, and underwater ground truthing of newly documented and previously recorded high probability targets. The results of this investigation is enclosed as an executive summary entitled Phase 1 and 2 Submerged and Shoreline Cultural Resources Investigation, Brigantine to Hereford Inlet, Atlantic and Cape May Counties, New Jersey, Army Corps of Engineers, Philadelphia District (Cox, 1995). Ground truthing operations and re-analysis of survey data suggests that five targets in Borrow Area 1 are potential shipwreck sites. No remote sensing targets were identified in the Longport Borrow Area.

As a result of our review of the above reports, the Corps has found that the proposed dredging activities in Borrow Area 1 could cause physical destruction or damage to five potentially significant magnetic anomalies. However, it is our position that the impacts can be avoided and that measures can be taken to ensure that the project will have no effect on the submerged resources. Each target will be avoided during proposed dredging operations by delineating a 200 foot buffer around each location. The District anticipates that sand placement will have no effect on the two pier structures.

Please review the enclosed documentation and provide this office with your opinion regarding our "No Effect" finding within 30 days of the date of this letter. Should you have any questions regarding this matter, please contact Michael Swanda, Environmental Resources Branch, at (215) 656-6556 or by writing to the above address.

Sincerely,

Robert L. Callegari
Chief, Planning Division

Enclosure

Copies Furnished:
CENAP-PL-PC, Gaffney

State of New Jersey

Christine Todd Whitman
Governor

Department of Environmental Protection
DIVISION OF PARKS AND FORESTRY
HISTORIC PRESERVATION OFFICE
CN-404
TRENTON, N.J. 08625-0404
TEL: (609) 292-2023
FAX: (609) 984-0578

Robert C. Shinn, Jr.
Commissioner

HPO-A96-167
January 19, 1996

Mr. Robert L. Callegari
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Attn: Michael Swanda

Dear Mr. Callegari:

As Deputy State Historic Preservation Officer for New Jersey, in accordance with 36 CFR 800: Protection of Historic Properties, as published in the Federal Register September 2, 1986 (51 FR 31115-31125), I am providing Consultation Comments under Section 106 of the National Historic Preservation Act for the following project:

> Atlantic County, Multiple Municipalities
> Absecon Island: beach nourishment and two sand borrow areas near north end of Absecon Island
> United States Army Corps of Engineers

800.4 Identifying Historic Properties

To the best of my knowledge, no historic properties have been identified within the project impact zone. Consequently, pursuant to 800.4(d), this concludes the Section 106 process for the project, unless resources are discovered during implementation of the undertaking pursuant to 800.11.

ADDITIONAL COMMENTS

This finding is based in part on cultural resource surveys for the project conducted by Hunter Research, Inc. and Dolan Research, Inc. in 1995. As a result of this work, several shipwrecks and other potentially significant locations were identified. During the dredging operations, the Corps will avoid each target location identified by delineating a 200 foot buffer around each location.

The Office looks forward to receiving the final report for the project.

Thank you for providing this opportunity for review and consultation under Section 106 of the National Historic Preservation Act and for your stewardship of New Jersey's historic and prehistoric cultural resources. If you have any questions, please do not hesitate to contact Deborah Fimbel, staff reviewer for this project.

Sincerely,

Dorothy P. Guzzo
Deputy State Historic
Preservation Officer

DG:DF
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Spring 1996

US Army Corps of Engineers.
Philadelphia District

New Jersey Shore Protection Study UPDATE

Editor's note: the Corps of Engineers became active in fish and wildlife conservation with the Fish and Wildlife Coordination Act of 1958. Since then the Corps has taken on an increasingly prominent environmental role, with the scope of that role broadening as well. One very significant change occurred in 1990, when Congress added fish and wildlife restoration as a Corps mission — a "priority project output." That policy, which is still in effect, states that "... in investigating and planning any federal navigation, flood control, or multipurpose water resource project, full consideration shall be given to the opportunities, if any, which the project affords for fish and wildlife conservation and improvement... those structural and nonstructural measures that contribute to increasing the quantity of identified species and/or improving the quality of their habitat."

In other words, the Corps was given authority not only to maintain environmental quality, but to improve it.

The Philadelphia District has already carried out several restoration projects under this policy, with even more in the planning stages. Initiatives have included construction of artificial reefs, controlled burning of phragmites to allow revegetation with more productive species, and use of dredged materials to restore wetlands. This issue of the Update *takes a closer look at those environmental initiatives that are part of the New Jersey Shore Protection Study.*

Quantifying the value of environmental projects

How do you put a price tag on nature? You don't. But there are other ways to quantify the benefits associated with environmental restoration projects — one of which is the Habitat Evaluation Procedure (HEP).

Three of the Philadelphia District's four active feasibility studies for the New Jersey shore address the need for environmental restoration:

- Barnegat Inlet to Little Egg Inlet (erosion at the Holgate unit of Edwin B. Forsythe National Wildlife Refuge)
- Townsends Inlet to Cape May Inlet (erosion at the southern end of Stone Harbor near Hereford Inlet)
- Lower Cape May Meadows — Cape May Point (flooding in Cape May Point State Park and the Cape May Migratory Bird Refuge)

All the above involve looking for ways to stem the effects of erosion on valuable wildlife habitats.

If all projects had to be justified on *economic* benefits alone, there would be no point pursuing any of these initiatives. But HEP gives the district a way to identify *environmental* benefits, expressed not in dollars but in Habitat Units.

Here is how the Habitat Evaluation Procedure is used for a given habitat (such as a beach, forest, or marsh):

Photo courtesy of Island Beach State Park

1. District biologists, in close cooperation with the U.S. Fish and Wildlife Service, identify representative species within the habitat for which Life Requisite Factors have been identified in standard models. For each species there is one or more LRF addressing food, cover, breeding and/or other basic needs.
2. The planners then perform field surveys to determine all the LRF values for that habitat. An LRF of 1.0 (the highest possible) indicates optimal conditions for the species, all the way to zero for total unsuitability.
3. Based on predetermined formulas, individual LRF 's are combined into a Habitat Suitability Index for each representative species.

(See HABITAT EVALUATION PROCEDURE on page 6)

Study to study

..anasquan to Barnegat

The Manasquan Inlet to Barnegat Inlet Reconnaissance Study, which addressed coastal erosion and storm damage susceptibility along Island Beach, was completed in March. The draft report is undergoing the Corps' formal review process; a certified report for public release is expected in the next couple of months.

The study confirmed the need for construction of shore protection projects within the study area. The feasibility study would fully evaluate shore protection issues within the communities of Point Pleasant Beach, Bay Head, Mantoloking, Brick Township, Lavallette, Dover Township, Seaside Heights, Seaside Park and Berkeley Township.

NJDEP has indicated a willingness to cost-share in the feasibility study and in any subsequent construction projects.

However, in accordance with current Administration policy **(see page 6)**, the ~rps' fiscal 1997 budget does not ~ntain funds for the feasibility study.

Barnegat to Little Egg

After completion of the reconnaissance phase in 1995, the Barnegat Inlet to Little Egg Inlet Feasibility Study was put on hold due to the administration's policy on shore protection **(see page 6)**. Subsequent congressional action added $408,000 back into the Corps' fiscal 1996 budget, however, which allowed the study to begin in January of this year.

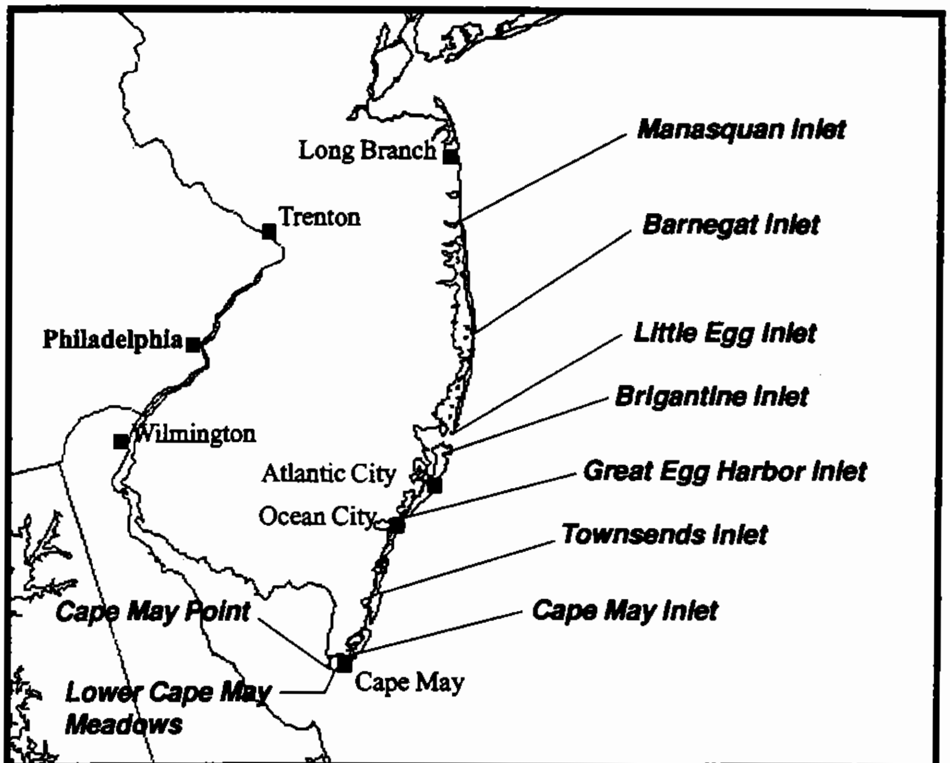
The study schedule from this point depends on annual appropriation funding. In other words, how the feasibility study will proceed beyond the current fiscal year is uncertain.

The study is exploring erosion and storm damage solutions throughout Long Beach Island. Loveladies, Harvey Cedars, Brant Beach and Beach Haven were identified among the more vulnerable communities.

The feasibility study also will be looking into effective protection and/or restoration measures to prevent a potential breach in the Holgate unit of Edwin B. Forsythe National Wildlife Refuge. This undeveloped barrier habitat is frequently flooded and overwashed by storms and even high tides. Measures to reduce flooding could make this area more suitable for a wide variety of nesting shorebirds.

In conjunction with this study, the Philadelphia District will be developing an aerial photography archive database for categorizing historic and existing shoreline changes on Long Beach Island.

Other upcoming tasks include obtaining digital orthophotography, which is used for contour mapping and ground "truthing" (verifying map data), and performing field inspections and



New Jersey Shore Protection Study Area

Project Name	Current/Last Phase	Finish	Comments
Manasquan Inlet to Barnegat Inlet	Reconnaissance	Mar-96	Next phase (feasibility) on hold, not funded
Barnegat Inlet to Little Egg Inlet	Feasibility	TBD	Current year funding restored effective January 1996
Brigantine Inlet to Great Egg Harbor Inlet • Absecon Island Interim Study • Brigantine Island Interim Study	Feasibility	 Oct-96 Nov-98	Next phase (plans and specifications) on hold, not funded
~reat Egg Harbor Inlet to Townsends Inlet	Reconnaissance	Apr-96	Next phase (feasibility) on hold, not funded
Townsends Inlet to Cape May Inlet	Feasibility	Mar-97	Next phase (plans and specifications) on hold, not funded
Lower Cape May Meadows — Cape May Point	Feasibility	Aug-98	Continuing

surveys of approximately 100 beach groins along the developed shoreline.

These surveys are needed to analyze the groin structures for functionality and current effectiveness with respect to shore protection. The terminal groin at the southern end of Beach Haven is of particular interest.

Brigantine to Great Egg Harbor

The district is conducting the Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study in two stages, split geographically at Absecon Inlet. The first stage, the Absecon Island interim study, is expected to be completed this October. The draft feasibility report was completed in December 1995 and was reviewed by the Corps' headquarters and NJDEP in February. The Absecon Island study reached a major milestone in May when the revised draft report with the draft Environmental Impact Statement went out for its 45-day public review period.

The report proposes a beachfill and dune for the oceanfront of Atlantic City, Ventnor, Margate and Longport, with periodic nourishment occurring every three years for the next fifty years. Additionally, two bulkheads are proposed for Atlantic City's inlet frontage in areas where storm inundation occurs.

The Brigantine Island interim study began last fall and will run through November 1998. Recent aerial photography of the area has been converted into digital orthophotography, which is used to generate accurate maps including topography and bathymetry.

Great Egg Harbor to Townsends

This study and the Manasquan Inlet to Barnegat Inlet study are at a similar stage. The reconnaissance report was completed in April and is currently under review.

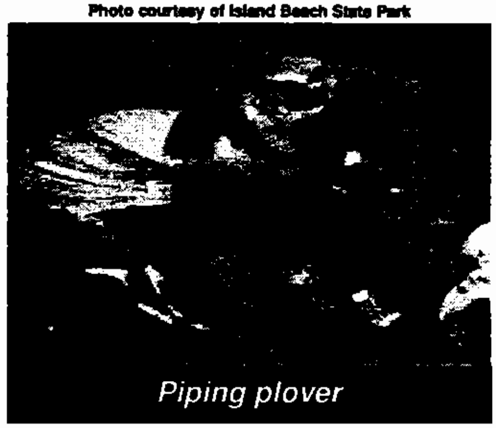
The report has identified that the primary problems along this 16-mile coastline stem from severe beach erosion and a resulting loss of protection. Storms of moderate intensity during the winters of 1991 to 1993 caused considerable damage, testifying to the potential devastation during a major event.

The biggest factor for most of the Great Egg Harbor Inlet to Townsends Inlet study area — including Strathmere, Sea Isle City and the south end of Ocean City — has been loss of dunes since the major storms of 1991, 1992 and 1996. At Sea Isle, erosion persists at the southern end.

Townsends to Cape May

Shore protection alternatives are being evaluated along the oceanfronts of Avalon and Stone Harbor and the inlet frontages of Avalon and North Wildwood. Evaluations consist of hydraulic performance during storms and the economics of damage prevention to determine the optimal project. The draft feasibility report is scheduled for completion in July. As with the Absecon Island report, it will be reviewed by the Corps' headquarters prior to release for public comment. The final feasibility report is scheduled for January 1997.

Photo courtesy of Island Beach State Park



Piping plover

In addition to the traditional shore protection issues, a significant portion of the study focuses on erosion at the undeveloped wildlife conservation area at the southern end of Stone Harbor, adjacent to Hereford Inlet. In conjunction with the U.S. Fish and Wildlife Service, NJDEP and the Borough of Stone Harbor, the district has identified coastal bayberry as the habitat of prime importance.

The district is investigating possible causes for the erosion, impacts on the surrounding community, and a range of environmentally sensitive solutions. These solutions will be incrementally analyzed using the Habitat Evaluation Procedure (see page 1).

The Meadows – Cape May Point

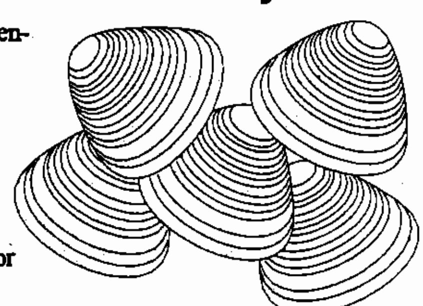
The Lower Cape May Meadows — Cape May Point Feasibility Study, which was approved mainly on the basis of "environmental quality" benefits, is now moving forward with strong support from the White House and is due for August 1998 completion.

The undeveloped 350-acre Lower Cape May Meadows, which includes Cape May Point State Park and the Cape May Migratory Bird Refuge, is one of the most important migratory bird stopovers in North America, and is also home to threatened and endangered birds such as the piping plover. Erosion and overtopping during storms continue to seriously threaten this vital habitat.

District planners are exploring several options for the Meadows, including beach replenishment, restoration of interior wetlands, water level management and phragmite control.

The feasibility study is also addressing the flooding and storm damage problems at Cape May Point, which is just east of Lower Cape May Meadows.

Results from benthic surveys show growth in surf clam numbers off the Jersey shore



When the Corps looks for suitable open-water sand borrow areas for beachfill projects, it must evaluate benthic (ocean floor) organisms in and around potential locations, with the goal of minimizing negative impacts to those organisms. The Philadelphia District contracts with private firms to conduct benthic surveys for this purpose.

These surveys also act as an indicator of the overall health of New Jersey's coastal waters. One recent survey identified 83 distinct species of benthic invertebrates, including surf clams, alive and well off the Jersey shore — particularly good news in light of ongoing concerns over the vitality of surf clams in this area!

District planners and engineers call on ACES to organize, analyze a wide variety of coastal data

Just as the last *Update* (September 1995) highlighted the Philadelphia District's use of Geographic Information Systems, this issue looks at how another computer application — the Automated Coastal Engineering System — helps district planners and engineers with the increasingly complex task of data assimilation and analysis.

Developed by the Corps' Coastal Engineering Research Center, ACES is a collection of coastal engineering calculations, algorithms and models that is widely used in industry and academia as well as by the Corps. It includes many different types of wave calculations, coastal structural design routines and littoral process applications.

Due to the increasing complexity of coastal engineering models being developed, CERC has begun work to upgrade ACES technology from the PC to a more powerful UNIX-based workstation platform.

The latest ACES upgrade (version 2.0) represents the link between greatly expanding coastal data bases, GIS, numerically intensive coastal modelling software, and enhanced visualization of the model results. In support of this upgrade, CERC has established an ACES Pilot Committee to steer the course of future model integration efforts, including Risk and Uncertainty tools.

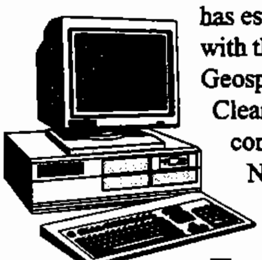
During one recent meeting, the committee stressed the need to get its new software into the hands of intended users as soon as possible for field testing. As part of the New Jersey Shore Protection Study, the Philadelphia District is looking to participate in this testing while improving the quality of its modelling efforts.

In conjunction with hosting the next ACES Pilot Committee this fall (date to be announced), the Philadelphia District is planning a one-day workshop that will include a hands-on demonstration of ACES 2.0.

Access this Web site to get geospatial data

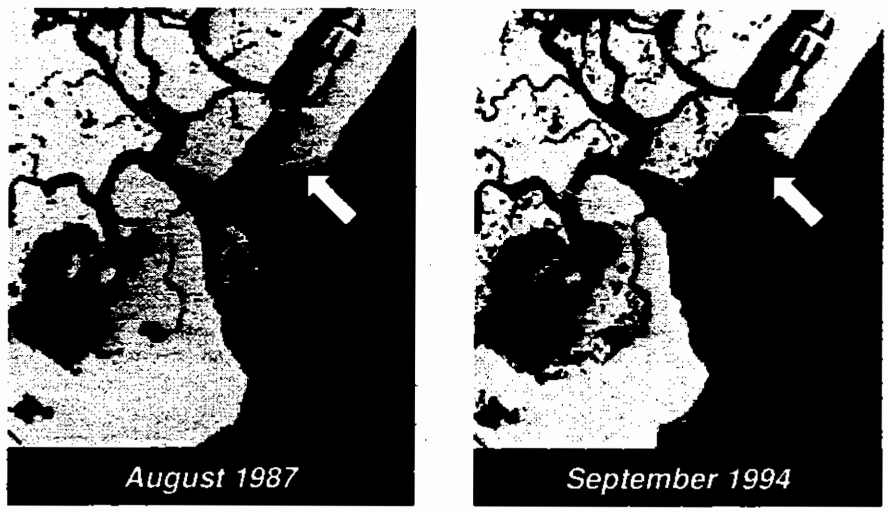
Did you know that you can obtain up-to-date geospatial data on the World Wide Web?

The U.S. Army Corps of Engineers has established a site with the National Geospatial Data Clearinghouse, a component of the National Spatial Data Infrastructure.



The site web address is ***http://corps_geo1.usace.army.mil***.

Or you can start your "web surfing" at ***http://www.usace.army.mil***, the Corps home page. From this point you can access a wealth of information about not only the Corps' role in shore protection, but also its many other areas of involvement.



Satellite images shed new light on changes to Jersey shoreline over seven-year period

Evaluating habitats in coastal study areas depends primarily on field surveys, but most of the information gained from those surveys reflects *present* conditions. But the Corps also must take into account what changes have taken place over time.

Remote sensing technology has proven to be one very useful tool for identifying long-term shoreline changes and loss of habitat. The Philadelphia District recently contracted with the University of Delaware, a forerunner in remote sensing applications for coastal habitat analysis, to do a pilot study for Stone Harbor and Hereford Inlet. Existing aerial photography was then used to georeference the remote sensing images.

Contrasting SPOT satellite images **(above)** from 1987 and 1994 show pronounced erosion at the southern end of Stone Harbor **(see white arrows)** over that seven-year period. The actual color images also revealed inlet morphology changes, such as in shoaling patterns and depths, as well as distribution of habitat types according to spectral signature — how different plants reflect light — and where habitats have changed. For instance, what was an upland sandy beach in 1987 might have become an intertidal wetland by 1994, while another location formerly underwater might now be classified as upland.

Satellite imagery classification through remote sensing has enriched the district's data collection and analysis efforts for the Townsends Inlet to Cape May Inlet study, and planners are already looking to apply this proven technology in other areas.

Your feedback matters to us

The Philadelphia District highly values your involvement. Your concerns and ideas become increasingly important as we move into the planning and development of specific coastal projects.

If you have any comments on the New Jersey Shore Protection Study, or changes for our mailing list, please cut along the dotted line and mail the completed form to this address:

U.S. Army Corps of Engineers
ATTN: CENAP-PL-PC
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

_____ YES. Please correct my address or add it to the New Jersey Shore Protection Study mailing list.

_____ NO. Please delete my name from the mailing list.

NAME: ____________________

ADDRESS: ____________________

COMMENTS:

Habitat Evaluation Procedure

(from page 1)

4. Finally, the HSI's for all species are multiplied by the habitat acreage to calculate the number of Habitat Units per species.

This information enables planners to identify valuable habitats, quantifying how much of those habitats have been lost, what more would be lost if no action is taken, and what effect various initiatives might have on stemming and restoring those losses.

As environmental restoration alternatives are identified, they must be evaluated in terms of benefits and costs. So now for the next problem: How do you relate HU's to dollars? That would be a problem if the Corps was restricted to the least-cost alternative, as with projects justified on an economic basis.

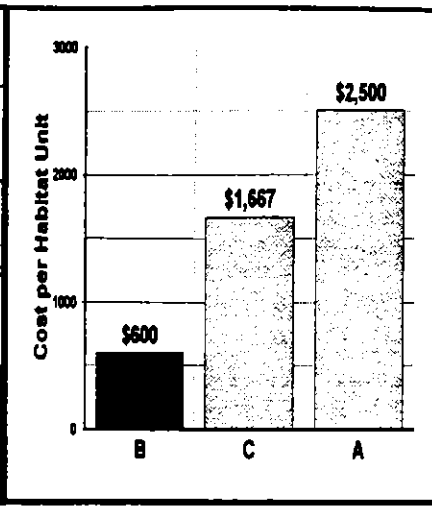
In this case, however, the focus is on *incremental* cost. Planners look for a break point at which an additional dollar spent yields a minimal increase in HU's.

Consider a purely hypothetical example of three environmental restoration alternatives **(see table above)**. Based on incremental analysis, Alternative B is the best choice. It yields far greater environmental benefits than Alternative A at only a slightly higher cost, while the additional gains from Alternative C are minimal compared with the additional investment required. Comparing the three by cost *per habitat unit* **(see graph above)**, the result is the same.

The Habitat Evaluation Procedure offers an objective, common-sense approach to decision making for environmental restoration. It is certain to play a key role in the Philadelphia District's planning process for years to come.

Alternative	Habitat Units (HU's) added	Project Cost
A	200	$500,000
B	1000	$600,000
C	1200	$2,000,000

Comparing alternatives for environmental restoration



About this study

In 1989 the U.S. Army Corps of Engineers initiated the New Jersey Shore Protection Study to address beach erosion, water quality, and storm damage along the coast.

The initial limited reconnaissance study, completed in September 1990, recommended six areas between Manasquan Inlet and Cape May for further study.

All six studies have progressed at least through the reconnaissance phase, with four now in the feasibility phase and two on hold **(see table on page 2)**. The Corps' local sponsor for project funding is the New Jersey Department of Environmental Protection.

The future of shore protection

As stated in the last Update, the Clinton Administration has proposed that the Corps of Engineers no longer be involved in shore protection. Under current administration policy, the Corps will complete any project phase (reconnaissance, feasibility, design or construction) already underway, but proceed no further.

The one study area affected by this policy in 1995 was Long Beach Island, where the Corps could proceed no further after completion of the reconnaissance phase. But in January, work began on the Barnegat Inlet to Little Egg Inlet Feasibility Study after Congress added it to the Corps' fiscal 1996 budget. Progression beyond fiscal 1996 will require similar action, however.

For any other study area to move forward past its current phase, it will also have to be funded by Congress on an exception basis, like Long Beach Island. And even then there is no guarantee that funding will carry over to the following fiscal year.

With the likely exception of certain environmental initiatives (such as The Meadows), the prospects for continued federal funding of shore protection projects are still very lean. Thus local involvement — and local responsibility — is becoming all the more critical.

Commander and District Engineer .... **Lt. Col. Robert P. Magnifico**
Chief, Public Affairs .... **Richard H. Chlan**
Editor .... **Ed Voigt**

The NEW JERSEY SHORE PROTECTION STUDY UPDATE is an unofficial publication authorized under AR 360-81. Circulation: 1,000. Editorial views and opinions are not necessarily those of the U.S. Army Corps of Engineers or the Department of the Army. Issues are distributed to community, government and business organizations affected by the Philadelphia District's shore protection activities in New Jersey.

Letters to the editor are welcomed and encouraged. Address mail to: Editor, NEW JERSEY SHORE PROTECTION STUDY UPDATE, U.S. Army Corps of Engineers, Wanamaker Building, 100 Penn Square East, Philadelphia, Pa., 19107.

CENTER OF EXCELLENCE PHILADELPHIA DISTRICT

JAMES WHELAN
MAYOR

May 17, 1996

Mr. Robert L. Calligari
U.S. Army Corps of Engineers
Environmental Resources Branch
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

**RE: Public Notice
Absecon Island Interim Feasibility Study**

Dear Mr. Calligari:

Please be advised that the City of Atlantic City formally endorses the project plan as identified by Public Notice No. CENAP-PL-F-96-02.

In accordance with meetings with the USACE, NJDEP, Atlantic City Staff and Killiam Associates, we would respectfully request you provide consideration for the following within the final project design plans:

1. Coordinate the dune height with the elevation of Atlantic City boardwalk with special consideration for the limitations of the visual impact on visitors to our community.

2. Steepen the proposed landward dune slope of 1V:5H to approximately IV:4H and situate the dune as necessary to increase the free area between the dune toe and boardwalk to allow Atlantic City to continue to maintain the boardwalk and traditional recreational activities in this area.

3. Incorporate the necessary rehabilitation of groin systems and outfalls within the project scope, as necessary, and discuss cost sharing with reimbursement by Atlantic City on these improvements.

Executive Department, Room 706, City Hall, Atlantic City, New Jersey 08401 Phone: (609) 347-5400 FAX: (609) 347-5638

4. Integrate our "geotube" activities and efforts within the scope of the project to assure a comprehensive approach to the treatment of same.

We would be please to have our Engineer, staff and consultants discuss the above request at further length with your office as the project design develops and in support of your project activities.

Sincerely,

James Whelan
MAYOR

JW/jd

cc: William Rafferty, PE
Robert Levy, Jr., Director - Emergency Management
Robert C. Mainberger

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

Natural and Historic Resources
Division of Engineering and Construction

June 28, 1996

Honorable Frank A. LoBiondo
Member of Congress
Attn: Craig
513 Cannon H.O.B.
Washington, DC 20515

Dear Congressman LoBiondo:

In response to your recent inquiry, this is to advise that the Department is in total support of the current shore protection study from Brigantine Inlet to Great Egg Harbor Inlet.

This project will provide storm protection to Brigantine and Absecon Island communities. The past coastal storms have inflicted heavy damage to the communities of Atlantic City, Ventnor, Margate and Longport. The public support for this project is overwhelming. There is a very urgent need for this project to be included in the Water Resource Development Act of 1996. The Department stands ready and willing to cost share the PEN&D phases of this work and when construction is ready, all of the necessary funds will be in place to undertake this vital project.

Due to the uncertainty of future Federal involvement in shore protection, it is of the utmost importantance that this project be included in the Water Resource Development Act of 1996. The State stands ready to sign the necessary PCA and to obtain all the necessary easements and right-of-ways that are required.

Your help and assistance in moving this project forward will be greatly appreciated.

Sincerely,

Bernard J. Moore
Administrator

mm

c Phila. Dist. Corps of Engineers

Phone
(908) 255-0770

1510 Hooper Avenue, Toms River, NJ 08753

Fax
(908) 255-0774

APPENDIX G

PUBLIC REVIEW COMMENTS/RESPONSES

765

ID: AUG 26 '96 15:57 No.012 P.01

Post-it® Fax Note 7671

To John Burnes	Date 8/26/96 # of pages 3
Co./Dept. COE	From Richard Kropp
Phone # 215-656-6540	Co NJDEP
Fax # 215-656-6543	Phone # 609-984-3444
	Fax # 609-292-8115

Christine Todd Whitman
Governor

State of
Department of En

Commissione

August 26, 1996

Robert L. Callegari
Planning Division
Department of the Army
Philadelphia District
Philadelphia, Pennsylvania 19107

RE: Water Quality Certification and Federal
Consistency Statement Request
Absecon Island Dredging/Beach Fill Study
LURP File No. 0000-96-0002.2
Atlantic City, Ventnor, Margate and Longport
Atlantic County

Dear Mr. Callegari:

1. The New Jersey Department of Environmental Protection, Land Use Regulation Program, acting under Section 307 of the Federal Coastal Zone Management Act (P.L. 92-583) as amended, has reviewed the "Absecon Island Interim Feasibility Study, Volume 1," dated April 1996. Based on the information submitted the Program has determined that the project as discussed in the submitted feasibility study, is consistent with New Jersey's Rules on Coastal Zone Management, N.J.A.C. 7:7E, as amended to August 19, 1996 and the applicable Rules guiding issuance of a Section 401 Water Quality Certificate, provided the conditions discussed below are met to the satisfaction of the Department.

Project Description

The project is intended to provide storm and erosion protection for the coastal communities of Atlantic City, Ventnor, Margate and Longport. The project includes the dredging and placement of sand on the beach with a periodic replenishment of dredged sand every 3 years over a 50 year project life. In addition, the plan provides for bulkheads at unprotected areas of the Absecon Inlet frontage.

This consistency determination is based on the following conditions being met:

1. Concur. The conditions of this letter will be met prior to any construction activities.

1. In Atlantic City, the selected plan berm width of 200 feet which maximizes net benefits from a federal standpoint may be less desirable than a lesser scale plan with potentially less environmental impact but approaching the selected alternative in storm damage protection. Since the destruction of surf clam areas is prohibited (7:7E-3.3), in order to reduce impacts to surf clam areas, an alternative with a lesser berm width (150', Alternatives CX or CY) must be implemented unless sufficient information is provided to demonstrate that these alternatives do not fulfill the project purpose or do not reduce impact to surf clam areas.

2. The proposed bulkhead sections should be located behind the beach and above the spring high water line in order to met the Rules concerning Beaches (7:7E-3.22), Intertidal and Subtidal Shallows (7:7E-3.15), Filling (7:7E-4.2(j)) and Coastal Engineering (Structural Shore Protection Structures) (7:7E-7.11(e)). Coordination with the Land Use Regulation Program during design studies must be accomplished to determine an alignment which meets these rules.

3. In order to meet the Surf Clam Areas Rule (7:7E-3.3), either utilize, or provide specifics which justify, to the Program's satisfaction, dismissing the use of, the interior of the Absecon Inlet site along Brigantine to reduce the destruction of surf clam areas. The information provided should evaluate areas outshore of the beaches and dunes. The information should also include a characterization of the substrate materials.

4. Locations and plans for access through the dunes must be provided in accordance with the requirements set forth in the Dune rule (7:7E-3.16) and the standards set forth at Subchapter 3A that are applicable.

5. The Army Corps of Engineers is required to provide the monitoring plan as described in the submitted feasibility study (page 202, paragraph 492) within 30 days of the date when the first funds for preconstruction engineering and design are received in the district. This monitoring plan was not included in the feasibility study. The monitoring plan must provide for the assessment of recolonization of the borrow area by surf clams.

6. In order to reduce the loss of surf clam areas, prior to deciding where to obtain borrow material for future beach replenishment, the previously used portions of the borrow area shall be evaluated and the expansion into unused portions of the borrow area restricted.

Revised plans and supporting information for each of the above conditions must be submitted to the Land Use Regulation Program for review and approval at least 90 days prior to soliciting bids on the project.

Pursuant to 15 CFR 930.44, the Program reserves the right to object and request remedial action if this project is conducted in a manner, or is having an effect on, the coastal zone which is substantially different than originally proposed.

If you have any questions concerning this determination please contact Catherine Krause, of my staff, at the above address or at (609) 984-0288.

Sincerely,

Richard Kropp, Director
Land Use Regulation Program

cc: Lawrence Schmidt
James Hall, Assistant Commissioner

State of New Jersey
DEPARTMENT OF COMMUNITY AFFAIRS
101 SOUTH BROAD STREET
CN-800
TRENTON NJ 08625-0800

May 03, 1996

Mr. Robert L. Callegari
Chief, Planning Division
Environmental Resources Branch
US Department of the Army
Philadelphia District, Corps of Engineers
Wanamaker Bldg., 100 Penn Square East
Philadelphia PA 19107-3390

RE: Absecon Island Interim Feasibility Study

Dear Mr. Callegari:

1. We have received information concerning a federal direct development activity to comply with Executive Order 12372 and the New Jersey State Review Process. This is to notify you that as of June 30, 1996, the end of the State fiscal year, the Intergovernmental Review Unit and the New Jersey Single Point of Contact (SPOC) role will cease to exist in New Jersey, thereby ending in New Jersey the implementation of the State Review Process for intergovernmental review pursuant to Presidential Executive Order 12372 and N.J.A.C. 5:50. This action is being taken by the Department as part of the reduction in the cost of government in New Jersey.

Since there will not be sufficient time for completion of the review cycle for your application by June 30th, no review through the State Review Process is required at this time. Please conduct usual notification procedures in effect for states without an Executive Order 12372 process.

The proper federal agencies are also being so notified, but you can expect some delay in this information reaching all those responsible for reviewing federal activities. It may be helpful if you provide a copy of this letter to the federal agency that reviews your compliance.

We appreciate your prior interest and cooperation. If you need further information, until June 28th please contact me at 609/292-9025. After that date, please contact the Office of the Assistant Commissioner for Aging and Women at 609/633-6205.

Sincerely,

Andrew Jaskolka
Administrator
Intergovernmental Review & Assistance Unit
Assistant Commissioner's Office

c: Gregory W. Adkins, Assistant Commissioner, New Jersey SPOC

1. No response required.

CITY OF ATLANTIC CITY

JAMES WHELAN
MAYOR

May 17, 1996

Mr. Robert L. Calligari
U.S. Army Corps of Engineers
Environmental Resources Branch
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RE: **Public Notice**
Absecon Island Interim Feasibility Study

Dear Mr. Calligari:

Please be advised that the City of Atlantic City formally endorses the project plan as identified by Public Notice No. CENAP-PL-F-96-02.

In accordance with meetings with the USACE, NJDEP, Atlantic City Staff and Killiam Associates, we would respectfully request you provide consideration for the following within the final project design plans:

1. Coordinate the dune height with the elevation of Atlantic City boardwalk with special consideration for the limitations of the visual impact on visitors to our community.

2. Steepen the proposed landward dune slope of 1V:5H to approximately IV:4H and situate the dune as necessary to increase the free area between the dune toe and boardwalk to allow Atlantic City to continue to maintain the boardwalk and traditional recreational activities in this area.

3. Incorporate the necessary rehabilitation of groin systems and outfalls within the project scope, as necessary, and discuss cost sharing with reimbursement by Atlantic City on these improvements.

1\. - 4.

Follow up telephone conversations confirmed Atlantic City's support for the Corps' originally recommended NED plan. The listed modifications to the recommended plan are simply topics that will be discussed between the Corps, non-Federal sponsor, and Atlantic City as part of the coordination of the final design details during the development of Plans and Specifications.

IX. REFERENCES

A. LITERATURE CITED

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B. PERSONAL COMMUNICATIONS

Norman, J. Biologist. 1996. New Jersey Bureau of Shellfisheries. New Jersey Department of Environmental Protection. Nacote Creek Research Station, Port Republic, New Jersey.

Wurst, K. Biologist. 1996. National Marine Fisheries Service. U.S. Department of Commerce. Sandy Hook, New Jersey.

APPENDIX A

Federally Listed Endangered and Threatened Species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED** species is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED** species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	**Shortnose sturgeon***	*Acipenser brevirostrum*	E
REPTILES	**Atlantic Ridley turtle***	*Lepidochelys kempii*	E
	Green turtle*	*Chelonia mydas*	T
	Hawksbill turtle*	*Eretmochelys imbricata*	E
	Leatherback turtle*	*Dermochelys coriacea*	E
	Loggerhead turtle*	*Caretta caretta*	T
BIRDS	**American peregrine falcon**	*Falco peregrinus anatum*	E
	Bald eagle	*Haliaeetus leucocephalus*	T
	Piping plover	*Charadrius melodus*	T
	Roseate tern	*Sterna dougallii dougallii*	E
MAMMALS	**Eastern cougar**	*Felis concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Blue whale*	*Balaenoptera musculus*	E
	Finback whale*	*Balaenoptera physalus*	E
	Humpback whale*	*Megaptera novaeangliae*	E
	Right whale*	*Balaena glacialis*	E
	Sei whale*	*Balaenoptera borealis*	E
	Sperm whale*	*Physeter macrocephalus*	E

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

SPECIES	SCIENTIFIC NAME
Bog turtle	*Clemmys muhlenbergii*
Bog asphodel	*Narthecium americanum*

Note: *Taxa formerly known as "Category 2" candidate species are now known as "species at risk." Species at risk are those species for which the Service does not have conclusive data to support listing the species under the Endangered Species Act at this time. Taxa formerly known as "Category 3B" or "Category 3C" candidate species are no longer considered candidate species or species at risk. Category 3B species were determined, on the basis of current taxonomic understanding, not to represent distinct taxa meeting the Act's definition of "species." Category 3C species are those species that have proven to be more abundant than previously believed and / or those that are not subject to any identifiable threat. If further research or changes in habitat indicate a significant decline in any of these taxa, they may be reevaluated for possible inclusion as candidate species or species at risk.*

For complete listings of taxa under review as candidate species or species at risk, refer to Federal Register Vol. 59, No. 219, November 15, 1994 (Animal) and Vol. 58, No. 188, September 30, 1993 (Plants).

Revised 6/96

APPENDIX B

Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act

United States Department of the Interior
FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
Hadley, MA 01035-9589

In Reply Refer To:
FWS/Region 5/ES-TE

APR 21 1994

Mr. John H. Spencer
Bureau of Natural Resources
Department of Environmental Protection
79 Elm Street
Hartford, Connecticut 06106-5127

Dear Mr. Spencer:

Enclosed are the U.S. Fish and Wildlife Service's Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act. This is the final version of the draft guidelines sent to you for review and comment on March 18, 1994.

These guidelines, based on the best available biological information, provide a flexible approach to protecting piping plovers, while minimizing impacts on beach recreation on non-Federal lands. Management techniques recommended in these guidelines will generally facilitate pedestrian access to the shoreline throughout the plover's breeding cycle. Recommended management options that include intensive monitoring will, in most cases, also allow use of motorized vehicles except when flightless chicks are present.

Please contact Anne Hecht at 508-443-4325 or Paul Nickerson at 413-253-8615 if you have questions about these guidelines or other aspects of the piping plover recovery effort.

Sincerely,

Ronald E. Lambertson

Regional Director

Enclosure

GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES
IN PIPING PLOVER BREEDING
HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF
THE ENDANGERED SPECIES ACT

Northeast Region, U.S. Fish and Wildlife Service
April 15, 1994

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service (Service), with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the Service's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have endangered species protection obligations under Section 7 of the Endangered Species Act (see section I below) or under Executive Orders 11644 and 11989[1] that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

This document contains four sections: (I) a brief synopsis of the legal requirements that afford protection to nesting piping plovers; (II) a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle; (III) guidelines for protecting piping plovers from recreational activities on Atlantic Coast beaches; and (IV) literature cited.

[1] Executive Order 11644, Use of Off-Road Vehicles on the Public Lands and Executive Order 11989, Off-Road Vehicles on Public Lands pertain to lands under custody of the Secretaries of Agriculture, Defense, and Interior (except for Indian lands) and certain lands under the custody of the Tennessee Valley Authority.

I. LEGAL CONSIDERATIONS

Section 9 of the Endangered Species Act (ESA) prohibits any person subject to the jurisdiction of the United States from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. A "person" is defined in Section 3 to mean "an individual, corporation, partnership, trust, association, or any other private entity; or any officer, employee, agent, department, or instrumentality of the Federal Government, of any State, municipality, or political subdivision of a State, or of any foreign government; any State, municipality, or political subdivision of a State; or any other entity subject to the jurisdiction of the United States." Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Penalties for violations of Section 9 are provided in Section 11 of the ESA; for threatened species, these penalties include fines of up to $25,000, imprisonment for not more than six months, or both.

Section 10 of the ESA and related regulations provide for permits that may be granted to authorize acts prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. States that have Cooperative Agreements under Section 6 of the ESA, may provide written authorization for take that occurs in the course of implementing conservation programs. For example, State agencies have authorized certain biologists to construct predator exclosures for piping plovers. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit, if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the Service determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized.

Section 7 of the ESA may be pertinent to beach managers and landowners in situations that have a Federal nexus. Section 7 requires Federal agencies to consult with the Service (or National Marine Fisheries Service for marine species) prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7 consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

Piping plovers, as well as other migratory birds such as least terns, common terns, American oystercatchers, laughing gulls, herring gulls, and great black-backed gulls, their nests, and eggs are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. Violators may be fined up to $5000 and/or imprisoned for up to six months.

Almost all States within the breeding range of the Atlantic Coast piping plover population list the species as State threatened or endangered (Northeast Nongame Technical Committee 1993). Various laws and regulations may protect State-listed species from take, but the Service has not ascertained the adequacy of the guidelines presented in this document to meet the requirements of any State law.

II. LIFE HISTORY AND THREATS FROM HUMAN DISTURBANCE

Piping plovers are small, sand-colored shorebirds that nest on sandy, coastal beaches from South Carolina to Newfoundland. Since 1986, the Atlantic Coast population has been protected as a threatened species under provisions of the U.S. Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1985). The U.S. portion of the population was estimated at 875 pairs in 1993 (U.S. Fish and Wildlife Service 1993). Many characteristics of piping plovers contribute to their susceptibility to take due to human beach activities.

LIFE HISTORY

Piping plovers begin returning to their Atlantic Coast nesting beaches in mid-March (Coutu et al. 1990, Cross 1990, Goldin 1990, MacIvor 1990, Hake 1993). Males establish and defend territories and court females (Cairns 1982). Eggs may be present on the beach from mid-April through late July. Clutch size is generally four eggs, and the incubation period[2] usually lasts for 27-28 days. Piping plovers fledge only a single brood per season, but may renest several times if previous nests are lost. Chicks are precocial[3] (Wilcox 1959, Cairns 1982). They may move hundreds of yards from the nest site during their first week of life (see Table 1, Summary of Chick Mobility Data). Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard et al. 1993).

Piping plover nests are situated above the high tide line on coastal beaches, sand flats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes. They may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells or cobble (Bent 1929, Burger 1987a, Cairns 1982, Patterson 1988, Flemming et al. 1990, MacIvor 1990,

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[2] "Incubation" refers to adult birds sitting on eggs, to maintain them at a favorable temperature for embryo development.

[3] "Precocial" birds are mobile and capable of foraging for themselves within several hours of hatching.

Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (Ammophila breviligulata) or other vegetation (Patterson 1988, Flemming et al. 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans or mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines[4], and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu et al. 1990, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu et al. 1990, McConnaughey et al. 1990, Loegering 1992, Goldin 1993, Hoopes 1993) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin et al. 1990). Feeding activities of chicks may be particularly important to their survival. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon (see Table 1). Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1993) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

THREATS FROM NONMOTORIZED BEACH ACTIVITIES

Sandy beaches that provide nesting habitat for piping plovers are also attractive recreational habitats for people and their pets. Nonmotorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush

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[4] Wrack is organic material including seaweed, seashells, driftwood and other materials deposited on beaches by tidal action.

eggs (Burger 1987b, Hill 1988, Shaffer and Laporte 1992, Cape Cod National Seashore 1993, Collazo et al. 1994). Unleashed dogs may chase plovers (McConnaughey et al. 1990), destroy nests (Hoopes et al. 1992), and kill chicks (Cairns and McLaren 1980).

Pedestrians may flush incubating plovers from nests (see Table 2, Summary of Data on Distances at Which Plovers React to Disturbance), exposing eggs to avian predators or causing excessive cooling or heating of eggs. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991). Excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Fireworks are highly disturbing to piping plovers (Howard et al. 1993). Plovers are particularly intolerant of kites, compared with pedestrians, dogs, and vehicles; biologists believe this may be because plovers perceive kites as potential avian predators (Hoopes et al. 1992).

THREATS FROM MOTOR VEHICLES

Unrestricted use of motorized vehicles on beaches is a serious threat to piping plovers and their habitats. Vehicles can crush eggs (Wilcox 1959; Tull 1984; Burger 1987b; Patterson et al. 1991; United States of America v. Breezy Point Cooperative, Inc., U.S. District Court, Eastern District of New York, Civil Action No. CV-90-2542, 1991; Shaffer and Laporte 1992), adults, and chicks. In Massachusetts and New York, biologists documented 14 incidents in which 18 chicks and 2 adults were killed by vehicles between 1989 and 1993 (Melvin et al. 1994). Goldin (1993) compiled records of 34 chick mortalities (30 on the Atlantic Coast and 4 on the Northern Great Plains) due to vehicles. Many biologists that monitor and manage piping plovers believe that many more chicks are killed by vehicles than are found and reported (Melvin et al. 1994). Beaches used by vehicles during nesting and brood-rearing periods generally have fewer breeding plovers than available nesting and feeding habitat can support. In contrast, plover abundance and productivity has increased on beaches where vehicle restrictions during chick-rearing periods have been combined with protection of nests from predators (Goldin 1993; S. Melvin, pers. comm., 1993).

Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitats in the wrack line and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings et al. 1990, Strauss 1990, Howard et al. 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes et al. 1992, Goldin 1993). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin et al. 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed (see Table 1).

Vehicles may also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate, by creating ruts that may trap or impede movements of chicks, and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes et al. 1992, Goldin 1993).

III. GUIDELINES FOR PROTECTING PIPING PLOVERS FROM RECREATIONAL DISTURBANCE

The Service recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NONMOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least 50 meter-radius around nests above the high tide line should be delineated with warning signs and symbolic fencing[5]. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of

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[5] "Symbolic fencing" refers to one or two strands of light-weight string, tied between posts to delineate areas where pedestrians and vehicles should not enter.

incubating adults, and to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach.

Available data indicate that a 50 meter buffer distance around nests will be adequate to prevent harassment of the majority of incubating piping plovers. However, fencing around nests should be expanded in cases where the standard 50 meter-radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance. Data from various sites distributed across the plover's Atlantic Coast range indicates that larger buffers may be needed in some locations (see Table 2). This may include situations where plovers are especially intolerant of human presence, or where a 50 meter-radius area provides insufficient escape cover or alternative foraging opportunities for plover chicks.[6]

In cases where the nest is located less than 50 meters above the high tide line, fencing should be situated at the high tide line, and a qualified biologist should monitor responses of the birds to passersby, documenting his/her observations in clearly recorded field notes. Providing that birds are not exhibiting signs of disturbance, this smaller buffer may be maintained in such cases.

On portions of beaches that receive heavy human use, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. If nests are discovered outside fenced areas, fencing should be extended to create a sufficient buffer to prevent disturbance to incubating adults, eggs, or unfledged chicks.

[6] For example, on the basis of data from an intensive three year study that showed that plovers on Assateague Island in Maryland flush from nests at greater distances than those elsewhere (Loegering 1992), the Assateague Island National Seashore established 200 meter buffers zones around most nest sites and primary foraging areas (Assateague Island National Seashore 1993). Following a precipitous drop in numbers of nesting plover pairs in Delaware in the late 1980's, that State adopted a Piping Plover Management Plan that provided 100 yard buffers around nests on State park lands and included intertidal areas (Delaware Department of Natural Resources and Environmental Control 1990).

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observation and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31.

Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged.

MOTOR VEHICLE MANAGEMENT

The Service recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the Service or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

If data from several years of plover monitoring suggests that significantly more habitat is available than the local plover population can occupy, some suitable habitat may be left unposted if the following conditions are met:

1. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Estimates the number of pairs likely to nest on the site based on the past monitoring and regional population trends.

AND

B. Delineates the habitat that will be posted or fenced prior to April 1 to assure a high probability that territorial plovers will select protected areas in which to court and nest. Sites where nesting or courting plovers were observed during the last three seasons as well as other habitat deemed most likely to be pioneered by plovers should be included in the posted and/or fenced area.

AND

C. Provides for monitoring of piping plovers on the beach by a qualified biologist(s). Generally, the frequency of monitoring should be not less than twice per week prior to May 1 and not less than three times per week thereafter. Monitoring should occur daily whenever moderate to large numbers of vehicles are on the beach. Monitors should document locations of territorial or courting plovers, nest locations, and observations of any reactions of incubating birds to pedestrian or vehicular disturbance.

AND

2. All unposted sites are posted immediately upon detection of territorial plovers.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2000 meter-wide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each side of the brood. In some cases, highly mobile broods may require protected areas up to 1000 meters, even where they are intensively monitored. Protected areas should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles. In a few cases, where several years of data documents that piping plovers on a particular site feed in only certain habitat types, the Service or the State wildlife management agency may provide written concurrence that vehicles pose no danger to plovers in other specified habitats on that site.

Timing of Vehicle Restrictions in Chick Habitat

Restrictions on use of vehicles in areas where unfledged plover chicks are present should begin on or before the date that hatching begins and continue until chicks have fledged. For purposes of vehicle management, plover chicks are considered fledged at 35 days of age or when observed in sustained flight for at least 15 meters, whichever occurs first.

When piping plover nests are found before the last egg is laid, restrictions on vehicles should begin on the 26th day after the last egg is laid. This assumes an average incubation period of 27 days, and provides a 1 day margin of error.

When plover nests are found after the last egg has been laid, making it impossible to predict hatch date, restrictions on vehicles should begin on a date determined by one of the following scenarios:

1) With intensive monitoring: If the nest is monitored at least twice per day, at dawn and dusk (before 0600 hrs and after 1900 hrs) by a qualified biologist, vehicle use may continue until hatching begins. Nests should be monitored at dawn and dusk to minimize the time that hatching may go undetected if it occurs after dark. Whenever possible, nests should be monitored from a distance with spotting scope or binoculars to minimize disturbance to incubating plovers.

OR

2) Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions on vehicles should begin at least 5 days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the Service recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property, or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, eg. by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

1. Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.

2. Speed of vehicles should not exceed five miles per hour.

3. Use of open 4-wheel motorized all-terrain vehicles (ATVs) or non-motorized all-terrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded operators.

4. A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.

Essential vehicles should avoid driving on the wrack line, and travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

SITE-SPECIFIC MANAGEMENT GUIDANCE

The guidelines provided in this document are based on an extensive review of the scientific literature and are intended to cover the vast majority of situations likely to be encountered on piping plover nesting sites along the U.S. Atlantic Coast. However, the Service recognizes that site-specific conditions may lead to anomalous situations in which departures from this guidance may be safely implemented. The Service recommends that landowners who believe such situations exist on their lands contact either the Service or the State wildlife agency and, if appropriate, arrange for an on-site review. Written documentation of agreements regarding departures from this guidance is recommended.

In some unusual circumstances, Service or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the Service or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

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Table 1. Summary of Chick Mobility Data

Source	Location	Data
Patterson 1988 (p.40)	Maryland and Virginia	18 of 38 broods moved to feeding areas more than 100 meters from their nests; 5 broods moved more than 600 meters (distance measured parallel to wrackline).
Cross 1989 (p.23)	Virginia	At three sites, observers relocated broods at mean distances from their nests of 153 m +/-97m (44 observations, 14 broods), 32 m +/-7 m (8 observations, 3 broods), and 492 m +/-281 m (12 observations, 4 broods).
Coutu et al. 1990 (p.12)	North Carolina	Observations of 11 broods averaged 212 m from their nests; 3 broods moved 400-725 m from nest sites.
Strauss 1990 (p.33)	Massachusetts	10 chicks moved more than 200 m during first 5 days post-hatch while 19 chicks moved less than 200 meters during same interval.
Loegering 1992 (p.72)	Maryland	Distances broods moved from nests during first 5 days post-hatch averaged 195 m in Bay habitat (n=10), 141 m in Interior habitat (n=36), and 131 m in Ocean habitat (n=41). By 21 days, average movement in each habitat had, respectively, increased to 850 m (n=1), 464 m (n=10), and 187 m (n=69). One brood moved more than 1000 m from its nest.
Melvin et al. 1994	Massachusetts and New York	In 14 incidents in which 18 chicks were killed by vehicles, chicks were run over ≤ 10 m to ≤ 900 m from their nests. In 7 of these instances, mortality occurred ≥ 200 m from the nest.

Table 2. Summary of Data on Distances at which Piping Plovers React to Disturbance

Source	Location	Data
Flushing of Incubating Birds by Pedestrians		
Flemming et al. 1988 (p.326)	Nova Scotia	Adults usually flushed from the nests at distances <40 m; however, great variation existed and reaction distances as great as 210 m were observed.
Cross 1990 (p.47)	Virginia	Mean flushing distances in each of two years were 47 m (n=181, range = 5 m to 300 m) and 25 m (n=214, range = 2 m to 100 m).
Loegering 1992 (p.61)	Maryland	Flushing distances averaged 78 m (n=43); range was 20 m to 174 m. Recommended use of 225 m disturbance buffers on his site.
Cross and Terwilliger 1993	Virginia	Mean flushing distance for all years on all sites (Virginia plover sites, 1986-91) was 63 m (n=201, SD=31, range = 7 m to 200 m). Differences among years were not significant, but differences among sites were.
Hoopes 1993 (p.72)	Massachusetts	Mean flushing distance for incubating plovers was 24 m (n=31).
Disturbance to Non-incubating Birds		
Hoopes 1993 (p.89)	Massachusetts	Mean response distance (all ages, all behaviors) was 23 m for pedestrian disturbances (range = 10 m to 60 m), 40 m for vehicles (range = 30 m to 70 m), 46 m for dogs/pets (range = 20 m to 100 m), and 85 m for kites (range = 60 m to 120 m).
Goldin 1993 (p.74)	New York	Average flushing distance for adult and juvenile plovers was 18.7 m for pedestrian disturbances (n=585), 19.5 m for joggers (n=183), and 20.4 m for vehicles (n=111). Pedestrians caused chicks to flush at an average distance of 20.7 m (n=175), joggers at 32.3 m (n=37), and vehicles at 19.3 m (n=7). Tolerance of individual birds varied; one chick moved 260 m in direct response to 20 disturbances in 1 hour.

APPENDIX C

Coordination with the
New Jersey Division of Fish, Game and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-96/17

June 21, 1996

Robert McDowell, Director
New Jersey Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625

Dear Mr. McDowell:

Enclosed is the U.S. Fish and Wildlife Service's (Service) Draft Fish and Wildlife Coordination Act Report entitled, "Assessment of the Absecon Island Interim Feasibility Study, Atlantic County, New Jersey." This constitutes the Service's report on fish and wildlife impacts that can be expected to result from the U.S. Army Corps of Engineers (Corps) proposed plan to construct the Absecon Island Project. This report has been prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and is for inclusion in the Corps Final Detailed Project Report and Environmental Assessment.

The Service's report contains an assessment of the proposed plan and recommendations for protection of fish and wildlife resources. Please provide a letter of comment including indication of concurrence, or lack thereof, within 20 days from the date of this letter. If there are any questions concerning this report, please contact John Staples or Eric Schrading of my staff.

Thank you for your assistance in this matter.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

Shallow Water Habitat

The proposed bulkhead between Atlantic Avenue and Oriental Avenue along the seaward edge of the existing boardwalk would result in the loss of a relatively large area of shallow water and intertidal habitat. The Corps determined that the proposed bulkhead was necessary at the seaward edge of the existing boardwalk in order to protect the existing boardwalk. Relocation of the boardwalk landward was considered in the Corps alternatives analysis, but was eliminated from further consideration because the cost outweighed the benefits. However, the boardwalk relocation alternative was not considered in combination with construction of a bulkhead. Relocating the boardwalk landward and constructing the bulkhead on the seaward side of the boardwalk would eliminate impacts on shallow water habitat and may be economically feasible since benefits appear to outweigh the costs, based on figures presented in the Corps alternatives analysis (U.S. Army Corps of Engineers, 1996). Therefore, the Department recommends that the Corps relocate the boardwalk landward between Atlantic Avenue and Oriental Avenue and construct a bulkhead and revetment on the seaward side of the boardwalk, in order to minimize impacts on shallow water habitat.

ENDANGERED SPECIES ACT COMMENTS

The federally listed threatened piping plover (*Charadrius melodus*) nests within 1.0 mile of the proposed project site. Piping plovers nest on sandy beaches above the high-tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand.

Food for adult plovers and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

Development along the coastal shoreline for residential and commercial uses, and the subsequent stabilization of the once-shifting and dynamic beach ecosystem via seawalls, breakwaters, jetties, and groins have resulted in the destruction and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for the piping plover. The U.S. Fish and Wildlife Service (Service) expects that the likelihood of piping plovers or other shorebirds currently nesting on the beaches within the project area is low due to the narrow width of the beach and extensive human disturbance. However, the proposed beach nourishment may create suitable nesting habitat so that piping plovers (and other beach nesting birds such as black skimmers (*Rynchops niger*), least terns (*Sterna antillarum*), and common terns (*Sterna hirundo*)) may use it in future seasons. For example, recent beach renourishment at Ocean City, New Jersey has resulted in the creation of piping plover nesting habitat that did not exist prior to project construction. Unfortunately, high levels of human activity on nourished beaches often eliminates nesting success (U.S. Fish and Wildlife Service, 1988). As a result, occurrence and nesting of federally listed or State-listed threatened or endangered species may require restrictions on some recreational activities and beach management activities (e.g., beach raking) to protect these species from adverse impacts.

Further coordination between the Corps and the Service would be necessary in the event that piping plovers nest on the beaches within the project area before beach nourishment is completed. The Service will likely recommend seasonal restrictions on current construction activities if piping plovers are identified on project area beaches. Should piping plovers use these beaches, protective zones will be established in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines) dated April 15, 1994 (see enclosure). Establishment of protective zones would be coordinated with the appropriate municipalities by the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program (ENSP). The Corps would be responsible for providing materials (e.g., fencing, signs) or funds for materials for such protective zones. Additionally, further consultation with the Service pursuant to Section 7 of the Endangered Species Act would be required by the Corps for each renourishment phase of the project for the project life (i.e., 50 years) on beaches where piping plovers are documented. Consultation on future renourishment phases may result in seasonal restrictions of construction activities.

In order to prevent future misunderstanding regarding the protection of piping plovers, the Department recommends that the Corps notify each municipality on Absecon Island (e.g., Atlantic City, Ventnor, Margate, and Longport) regarding the potential for recreational activity and beach management (e.g., beach raking) restrictions if piping plovers occur on the beaches of Absecon Island. In addition, each municipality should receive a copy of the above-mentioned Guidelines to become familiar with possible restrictions on recreational activities and beach management. The purpose of notifying municipalities in advance is to clarify the responsibilities of the municipalities that are benefiting from the proposed federal project. If municipalities are unwilling to cooperate with the Corps and the Service regarding piping plover management, the Corps should eliminate the municipality from the proposed project.

In the event that beach nesting birds do nest on Absecon Island, the Department recommends that the Corps develop effective educational materials (e.g., brochures, informational signs) and provide funds for public education and outreach. Development of informational materials would educate beach users about beach nesting birds, thereby reducing disturbance to nesting areas. Public education would also promote public support for protecting beach nesting birds.

Finally, the Department recommends that the Corps develop and implement a shorebird monitoring program in cooperation with the Service that monitors the use of the proposed nourished beaches for shorebirds, in particular piping plovers. An effective shorebird monitoring program would be designed to identify and report use of the project area beaches by shorebirds, particularly the piping plover, for the life of the project (i.e., 50 years). The Department requests that the Corps submit the proposed shorebird monitoring program to the Service for review and comment.

SUMMARY COMMENTS

The proposed project area is in a highly-developed region of New Jersey that currently supports limited fish and wildlife resources. Overall, implementation of the Absecon Island project would enhance fish and wildlife habitat within the project area. Enhancement would be accomplished by creating a wider beach and establishing a dune complex to include 91 acres of planted dune grass. However, by creating a wider beach and a dune complex, the possibility of piping plover and other shorebird use of the project area would increase. Potential use of the project area beaches by humans and the above-mentioned birds may conflict. Thus, monitoring and appropriate management would be required to minimize such conflicts.

It is the view of the Department that project-related adverse impacts to fish and wildlife could be minimized by incorporating the following recommendations into the final project design.

1. Consult with the New Jersey Bureau of Shellfisheries to minimize impacts on surf clams at Borrow area "A".

1. As stated by the Department, borrow area "D" was not chosen due to its distance from the proposed project. The Corps will continue to coordinate with the New Jersey Bureau of Shellfisheries and other agencies to ensure that impacts to surf clams are minimized to the greatest extent possible. Techniques proposed to minimize surf clam impacts are discussed in Sections 5.5.4.1 and 5.16.1 of the FEIS.

2. Avoid creating excessively deep, poorly flushed borrow areas.

3. Use a hydraulic-pipeline dredging method and schedule dredging during the period of lowest biological activity (November to January) to minimize impacts on benthic organisms.

4. Conduct each renourishment dredging phase in a limited area of Borrow area "A" and alternate locations for each subsequent renourishment cycle (rotational dredging).

5. Provide the federal resource agencies (e.g., Service and National Marine Fisheries Service) with copies of borrow area update surveys, the benthic monitoring program, and results of the benthic monitoring program.

6. Obtain a perpetual deed restriction or conservation easement for the newly created beach and adjacent beach areas

7. Relocate the boardwalk landward between Atlantic Avenue and Oriental Avenue and construct a bulkhead and revetment on the seaward side of the boardwalk, in order to minimize impacts on shallow water habitat.

8 Coordinate with the Service prior to initial beach nourishment to ensure that piping plovers do not occur on the project area beaches.

9. Establish protective zones, if piping plovers use these beaches after initial beach nourishment, in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act." The Corps would be responsible for providing materials (e.g., fencing, signs) or funds for materials for establishing such protective zones.

10. Consult with the Service pursuant to Section 7 of the Endangered Species Act for each renourishment phase of the project for the project life (i.e., 50 years) on beaches where piping plovers are documented.

11. Notify each municipality on Absecon Island about the restrictions that will be placed on recreational activities and beach management (e.g., beach raking) if piping plovers occur on the beaches of Absecon Island. In addition, the Corps should provide each municipality with a copy of the above-mentioned Guidelines.

12. In the event that beach nesting birds do nest on Absecon Island, develop effective educational materials or provide funds for public education and outreach to inform the public about beach nesting birds and promote public support for these species.

2. For the purposes of this project, the Absecon Inl. borrow area was designed to provide the required amount of sand for beachfill, while impacting the smallest amount of surface area possible. This was done primarily to minimize impacts to surf clams and other benthic organisms. During the dredging of sand from the inlet it will be necessary to excavate sand to a depth approximately 15 - 20 feet below its current elevation. Despite the depth of excavation required, the Corps does not believe the dredging will create excessively deep, poorly flushed borrow areas. Due to the fact that the proposed borrow area is located within an inlet, large quantities of water are moved through the area on a daily basis. In addition to providing the necessary water movement and flushing, it is believed that sand will be readily replaced at the site through the natural forces acting on the inlet.

3. The Corps will make every attempt to work within this recommended seasonal window. However, due to the size of this job, construction will most likely take several months, which may preclude the construction taking place only in the months of November to January. In addition, storms and severe weather conditions which are typical of this time of year may make construction during this time very challenging and possibly dangerous.

4. In order to minimize the impacts of renourishment on the benthic community the Corps will limit the size of the borrow area used during renourishment as much as possible. Also, the Corps will alternate the location of sand removal during subsequent nourishment cycles, providing that the deposition of sand within the borrow area allows for such a rotation.

5. All benthic monitoring data and borrow area information will be provided to the appropriate state and Federal agencies for review and coordination.

6. Concur. **The sponsor will be required to obtain perpetual beac nourishment and dune easements on all lands within the project area. Following completion of the project (50 yrs.), these easements will remain in effect for perpetuity.**

7. The Corps' analysis of relocating the boardwalk to a more landward position did include the consideration of the construction of the bulkhead as well. However, relocating the boardwalk in addition to the placement of the bulkhead was not economically feasible. Construction of the bulkhead in the Corps' recommended location requires backfilling to ensure the structural integrity of the bulkhead. This would result in the filling of approximately 0.3 acres of intertidal beach water area. This "beach", however, is principally comprised of remnant building rubble and is widely regarded by the sponsor and local community as being a visual blight with marginal environmental value and no recreational or other public use (refer to figure 23 on pg 98 of report). In addition, the shoreline in this area has been receding, with the proposed bulkhead location actually landward of the State's 1986 MHW line. The existing shoreline is expected to continue to erode, eventually requiring stabilization at a more landward position in the future. Therefore, the construction of the bulkhead at the recommended location would stabilize the shoreline along an area where it would ultimately be lost anyway. The backfill required for construction of the bulkhead would also improve the aesthetics of the area and create additional public use opportunities.

13. Develop and implement a shorebird monitoring program in cooperation with the Service that monitors the use of the proposed nourished beaches for shorebirds, in particular piping plovers. Additionally, submit the proposed shorebird monitoring program to the Service for review and comment.

The Department recommends that the Corps address or incorporate the above-mentioned concerns and recommendations in the Final Environmental Impact Statement. The Department and the Service will continue to cooperate fully to resolve these aforementioned concerns.

If you have any questions regarding these comments or require further assistance on issues regarding fish and wildlife resources in New Jersey, including federally listed threatened or endangered species, please contact the Service at the following address:

Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
Ecological Services
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
(609)646-9310

Thank you for the opportunity to provide these comments.

Sincerely,

Andrew Raddant
Regional Environmental Officer

Enclosure

8. Concur. As stated in Sections 5.6 and 5.16.3 of the FEIS the Corps will fully coordinate all construction activities with appropriate state and Federal agencies in the event that federally threatened piping plover, or other threatened or endangered species, are found within the project area. Information regarding the presence of piping plovers will be obtained prior to any construction or renourishment activities.

9. Concur. See above response.

10. Concur. See response for comment number 8.

11. The Corps will provide the requested information regarding piping plovers to all relevant cities and municipalities within the project area. In addition, the Corps will make sure that these areas are aware of possible restrictions that would be put in place in the event of piping plover nesting in the study area.

12. Concur. The Corps will work with state and Federal endangered species programs to ensure public awareness in the event that piping plovers are found nesting within the project area.

13. The New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Endangered and Nongame Species Program has an extensive monitoring program for piping plovers and other threatened and endangered species already in place. The Corps frequently coordinates efforts with this section of NJDEP and is kept fully aware of the presence of nesting plovers along the New Jersey Coastline. The Corps will continue to coordinate with the Endangered and Nongame Species Program to avoid any impacts to these and other threatened or endangered species.

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PERSONAL COMMUNICATIONS

Norman, J. 1996. Biologist. New Jersey Bureau of Shellfisheries. New Jersey Department of Environmental Protection. Nacote Creek Research Station, Port Republic, New Jersey.

cc: NJFO (2)
ARD/Northern
ARD/Central
NMFS, Gorski
USEPA, Hargrove
NHP, T. Breden
ENSP, L. Niles

NJFO:ES:ESchrading:eps:spr:6/11/96

Draft
FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE ABSECON ISLAND INTERIM FEASIBILITY STUDY, ATLANTIC COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

June 1996

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Tel: 609-646-9310
FAX: 609-646-0352

IN REPLY REFER TO:

FP-96/17

June 24, 1996

Lt. Colonel Robert P. Magnifico
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Magnifico:

This is the draft report of the U.S. Fish and Wildlife Service (Service) on anticipated impacts on fish and wildlife resources from the U.S. Army Corps of Engineers (Corps) proposed Absecon Island Project, Atlantic County, New Jersey. This report was prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*).

This draft report is provided in accordance with our Fiscal Year-1996 scope-of-work agreement and is based on plans and information provided in the Corps April 1996 Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Absecon Island Interim Study. The Service previously provided two Planning Aid Reports (PARs) entitled "Brigantine Inlet to Absecon Inlet, Brigantine Inlet to Great Egg Harbor Inlet Reach, New Jersey Shore Protection Reconnaissance Study" (August 1991) and "Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study, Atlantic County, New Jersey" (January 1995).

The peregrine falcon (*Falco peregrinus*), a federally listed endangered species, nests within the Absecon Island project area. The peregrine falcon has recently expanded its range and is now found nesting and hunting near urban areas. Peregrine falcons may be expected to forage for prey such as songbirds, gulls, terns, shorebirds, and wading birds within the project area. It is unlikely that the proposed project would adversely affect the peregrine falcon.

The federally listed threatened piping plover (*Charadrius melodus*) nests immediately south (in Ocean City, New Jersey) and north (in the City of Brigantine, New Jersey) of the proposed project area. Piping plovers nest on sandy beaches above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. While it is unlikely that piping plovers would nest on many of the beaches that are frequented by humans within the project area, nesting may become possible due to creation of suitable habitat as a result of the proposed project. The federally listed endangered Kemp's Ridley turtle (*Lepidochelys kempii*), hawksbill turtle (*Eretmochelys* *imbricata*), leatherback turtle (*Dermochelys coriacea*) and the federally listed threatened green turtle (*Chelonia mydas*), and loggerhead turtle (*Caretta caretta*) occur in the Atlantic Ocean immediately adjacent to the proposed project area. Except for nesting habitat for sea turtles, principal responsibility for marine turtles and marine mammals is under the jurisdiction of the National Marine Fisheries Service (NMFS). Occasional transient federally listed threatened and endangered species that may occur in the project area include the bald eagle (*Haliaeetus leucocephalus*). If piping plovers occur on the proposed project area during the life of the project (e.g., 50 years) further consultation pursuant to Section 7(a)(2) of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) would be required by the Service.

A draft copy of this report was forwarded to the New Jersey Division of Fish, Game and Wildlife (NJDFGW) for concurrence. A copy of the Service's letter to the NJDFGW is included as Appendix C of this report. The Service is currently awaiting NJDFGW's response to this draft report.

Additional information regarding this report can be provided by John Staples or Eric Schrading of my staff. The Service would appreciate any written comments on this report within 30 days.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

Draft

FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE ABSECON ISLAND INTERIM FEASIBILITY STUDY, ATLANTIC COUNTY, NEW JERSEY

Prepared for:

U.S. Army, Corps of Engineers
Philadelphia District
Philadelphia, Pennsylvania 19107-3390

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparer: Eric P. Schrading
Assistant Project Leader: John C. Staples
Project Leader: Clifford G. Day

June 1996

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, Philadelphia District (Corps) initiated the New Jersey Shore Protection Study, incorporating the Absecon Island Project, under the authority of resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987. The Absecon Island Project area is located on Absecon Island and incorporates the communities of Atlantic City, Ventnor, Margate, and Longport, Atlantic County, New Jersey.

The Absecon Island Project is designed to reduce the threat of storm damage and mitigate the effects of, or prevent, long-term erosion. The Absecon Island project involves the creation of a 200-foot-wide berm and a 25-foot-wide dune along the Atlantic City shoreline and a 100-foot-wide berm and a 25-foot-wide dune along the Ventnor, Margate, and Longport shorelines. The proposed berm and dune system would be renourished every 3 years for the life of the project (i.e., 50 years). Sand fencing and American beachgrass (*Ammophila breviligulata*) would be placed along the constructed dunes to entrap and maintain sand. The Corps also proposes to construct two bulkheads with associated revetments along the southern side of the Absecon Inlet. The Corps proposes to obtain the necessary beach nourishment material from three borrow areas in the Absecon Inlet, offshore of Absecon Island and offshore of Great Egg Harbor Inlet.

The Service is concerned about potential impacts on shellfish and other benthic organisms at the proposed borrow areas, the potential for residential or commercial development within the proposed beach nourishment area, and the potential use of the project area by the federally listed threatened piping plover (*Charadrius melodus*) and other beach nesting birds. It is the view of the Service that project-related adverse impacts to fish and wildlife could be minimized by incorporating several recommendations including rotational dredging, benthic fauna monitoring, deed-restricting the project area, monitoring the project area for piping plovers and other shorebirds, and consulting with the Service regarding appropriate actions if piping plovers initiate nesting in the project area.

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APPENDICES

I. INTRODUCTION

This constitutes the U.S. Fish and Wildlife Service's (Service), draft Fish and Wildlife Coordination Act, Section 2(b) report describing the fish and wildlife resources and supporting ecosystems in the area of the U.S. Army Corps of Engineers (Corps) proposed Absecon Island Project, which is associated with the Corps Brigantine Inlet to Great Egg Harbor Inlet Feasibility Study. This report is provided in accordance with a Fiscal Year-1996 scope-of-work agreement with the Corps Philadelphia District. The information presented in this report documents the fish and wildlife resources in the project area, identifies potential adverse impacts to those resources, provides recommendations to minimize adverse impacts, and identifies data gaps. The project area is located on Absecon Island and incorporates the communities of Atlantic City, Ventnor, Margate, and Longport, Atlantic County, New Jersey (Figure 1).

The New Jersey Shore Protection Study which incorporates the Absecon Island Project was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987. The authorization calls for defining coastal area problems and identifying potential solutions; identifying costs, environmental, and social impacts of potential solutions; and, presenting a optimized National Economic Development plan.

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U.S. Fish and Wildlife Service. 1996. Assessment of the Absecon Island Interim Feasibility Study, Atlantic County, New Jersey. Department of the Interior, Fish and Wildlife Service Fish and Wildlife Coordination Act Section 2(b) Report, New Jersey Field Office, Pleasantville, New Jersey.

Questions or comments regarding this report are welcomed by the Service. Written inquiries should be addressed to:

U.S. Fish and Wildlife Service
New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232

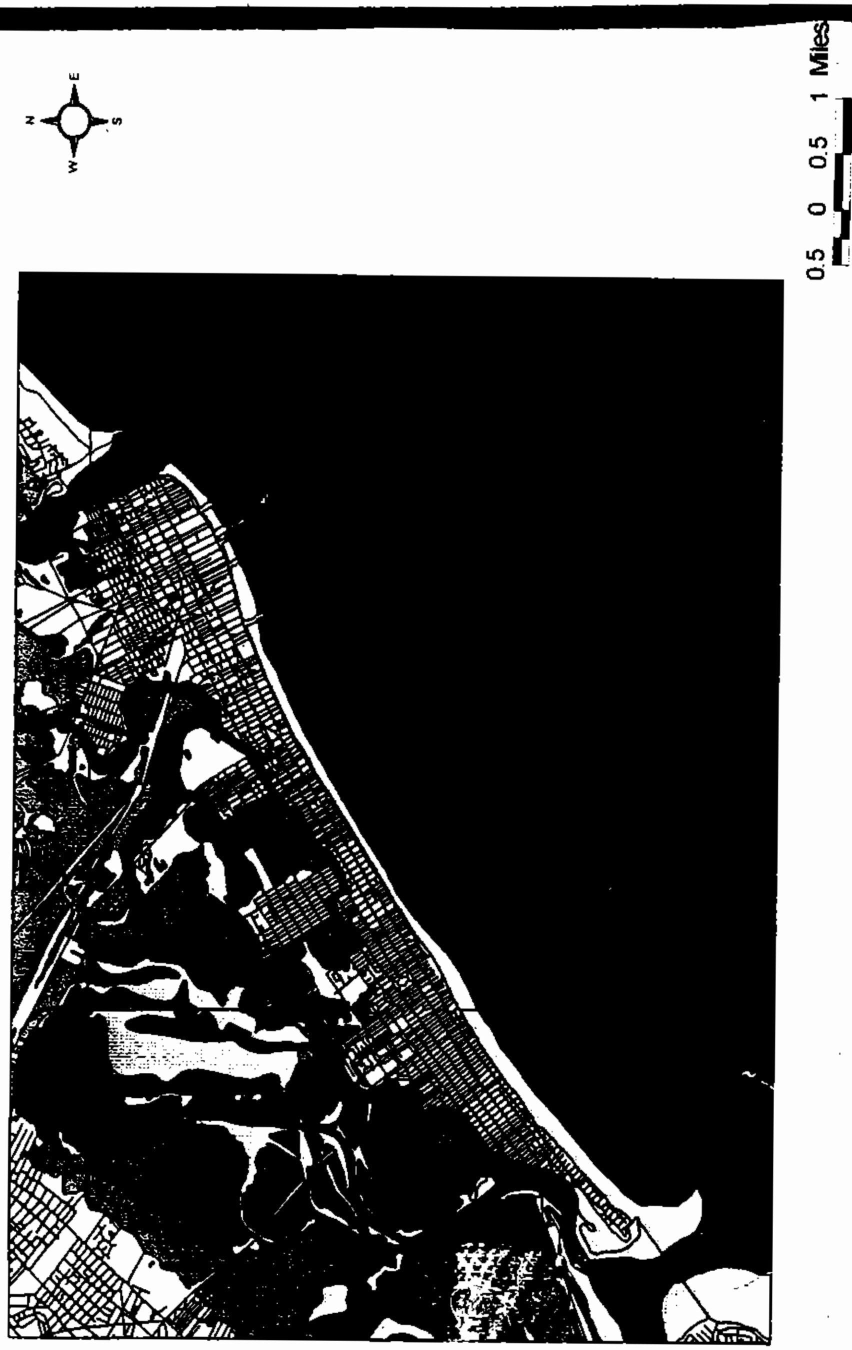

Figure 1. Project area for the Absecon Island Interim Feasibility Study.

II. PROJECT DESCRIPTION

The objectives of the Absecon Island Project are to:

1. reduce the threat of storm damage, with an emphasis on inundation and recession of the shoreline;

2. mitigate the effects of, or prevent long-term erosion;

3. enhance the recreational potential of the Atlantic City area as an incidental benefit; and

4. preserve and maintain the environmental character of the areas under study.

The proposed project would restore berms and dunes through beach nourishment and subsequent renourishment. In Atlantic City along the Atlantic Ocean, the Corps proposes to create a 200-foot-wide berm with a top elevation of +8.5 feet based on the National Geodatic Vertical Datum of 1929 (NGVD) (U.S. Army Corps of Engineers, 1996). A dune with a top elevation of +16 feet NGVD, side slopes of 1:5 (vertical:horizontal), and a top width of 25 feet would also be constructed. In Ventnor, Margate, and Longport, the Corps proposes only to construct a 100-foot-wide berm with a top elevation of +8.5 feet NGVD. A dune with a top elevation of +14 feet NGVD, side slopes of 1:5, and a top width of 25 feet would also be constructed. A transition from a 200-foot-wide berm to a 100-foot-wide berm would occur over a distance of 1,000 feet between Atlantic City and Ventnor. Approximately 6.2 million cubic yards of sand are required for the initial beach nourishment. Approximately 1,666,000 cubic yards of sand would be used every 3 years to renourish the proposed beaches throughout the project life (i.e., 50 years). In addition, 91 acres of American beachgrass (*Ammophila breviligulata*) and 63,675 linear feet of sand fence would be placed on the dunes to entrap and maintain sand. The Absecon Island Project also involves the construction of two timber sheet-pile bulkheads with associated revetments along the Absecon Inlet. The proposed bulkheads would be constructed from Madison Avenue to Melrose Avenue and Atlantic Avenue to Oriental Avenue and are 550 feet and 1,050 feet long, respectively (U.S. Army Corps of Engineers, 1996).

The Corps has identified three offshore borrow areas totalling 753 acres. The borrow areas are located within Absecon Inlet, offshore of Absecon Inlet, and offshore of Great Egg Harbor Inlet. The Corps intends to use the Absecon Inlet borrow area (Borrow area "A"), comprising 345 acres, initially and continue to use this borrow area until the available supply of sand in the borrow area is exhausted (U.S. Army Corps of Engineers, 1996). When material from Borrow area "A" is exhausted, the Corps would initiate use of another borrow area.

III. METHODS AND PROCEDURES

The information and findings presented in this report are based on review of the April 1996 Absecon Island Feasibility Study, Volume 1, Draft Feasibility Report and Draft Environmental Impact Statement (U.S. Army Corps of Engineers, 1996) and review of additional information made available to the Service by the Corps. The content of this report is also based on review of Service files and library material; coordination with the New Jersey Division of Fish, Game and Wildlife (NJDFGW); and, a site visit conducted on June 3, 1996.

IV. PHYSICAL CHARACTERISTICS

Absecon Island is bounded by Absecon Inlet to the north, Atlantic Ocean to the east, Great Egg Harbor Inlet to the south, and Beach Thoroughfare and Risleys Channel to the west. The Absecon Island contains the four communities of Atlantic City, Ventnor, Margate, and Longport, New Jersey. The Absecon Island is heavily developed as a residential and recreational area and includes numerous multilevel casinos and hotels. Absecon Island is a barrier island and is generally no more than 10 feet above mean sea level. The island currently has a relatively narrow beach and almost no dune system. The dunes that are present within the project area are small man-made dunes. The area west of Absecon Island is an extensive estuarine intertidal emergent wetland complex. Absecon Inlet north of Absecon Island is extensively used by recreational and deep draft commercial vessels. The Inlet provides a connection between the harbor of Atlantic City and the New Jersey Intracoastal Waterway.

V. FISH AND WILDLIFE RESOURCES

A. BENTHIC ORGANISMS

Benthic macroinvertebrates are important food organisms in the marine and estuarine environment, and, along with primary producers, perform a crucial role in supporting extensive food webs encompassing other forms of fish and wildlife. Approximately 250 species of benthic organisms are identified within the vicinity of the Absecon Island project area (Milstein and Thomas, 1976). Benthic organisms of interest in the shallow ocean waters and adjacent inlets and bays of the project area include Atlantic surf clam (*Spisula solidissima*), hard clam (*Mercenaria mercenaria*), and soft clam (*Mya arenaria*). The surf clam supports the largest molluscan fishery in New Jersey, accounting for 52 percent (by weight) of the State's total commercial landing in 1993 (New Jersey Bureau of Shellfisheries, 1994). The shallow ocean water immediately adjacent to the project area has been designated as a conservation

zone or a condemned area by the Surf Clam Advisory Committee. No surf clam harvesting is allowed within a conservation zone in order to promote recruitment and growth of current stock. Surf clam harvesting is also prohibited in condemned areas due to the lack of stock.

The Corps initiated two benthic organism assessment studies for each proposed offshore sand borrow site. The studies were initiated to establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow sites and identify the presence of commercial and/or recreationally important benthic macroinvertebrates. Borrow area "A" (Absecon Inlet) is characterized by relatively low infaunal abundance (mean=990 individuals/m^2) and low species diversity (mean=8 species). Borrow area "A" was dominated by haustoriid amphipods particularly *Parahaustorius* spp. and *Acanthohaustorius millsi* (Battelle Ocean Sciences, 1995). Borrow area "B" (Absecon Island Offshore) is characterized by relatively higher infaunal abundance (mean=1,700 individuals/m^2) and low species diversity (mean=12 species). A small archiannelid worm, *Polygordius* spp., and *Magelona papillicornis* are the predominant taxon in Borrow area "B" (Battelle Ocean Sciences, 1995). Battelle Ocean Sciences (1995) also identified the presence of surf clam at Borrow area "A" (mean=18 individuals/m^2) and Borrow area "B" (mean=23 individuals/m^2).

Versar, Incorporated (1995) assessed an additional portion of Borrow area "A", Borrow area "C" (Great Egg Harbor Inlet Offshore), and Borrow area "D" (Brigantine Inlet). Mean species diversity did not exceed 11 species and mean abundance was less than 2,000 individuals/m^2 in all borrow areas (Versar, Incorporated, 1995). Abundance was dominated by amphipods (greater than 80 percent), consisting primarily of *Protohaustorius* spp. and *Acanthohaustorius millsi*. Surf clam abundance was assessed using a commercial hydraulic clam dredge for three 5-minute tows in each borrow area. Surf clam abundance is relatively low in all borrow areas: Borrow area "A" (15-23 bushels, 145 clams/bushel), Borrow area "B" (25-50 bushels, 156 clams/bushel), Borrow area "C" (11-40 bushels, 232 clams/bushel), and Borrow area "D" (1-2 bushels) (Versar, Incorporated, 1995). Versar, Incorporated (1995) concluded that, except for the presence of surf clams, no significant attributes of the benthic community at the proposed borrow areas favor the selection of one borrow area over another.

B. FINFISH

A variety of finfish inhabit the shallow ocean waters within the project area. Trawl surveys conducted in the area between Holgate Peninsula and the Brigantine Inlet collected 76 species in 1974. The most numerous species were Atlantic menhaden (*Brevoortia tyrannus*), smooth dogfish (*Mustelus canis*), spiny dogfish (*Squalus acanthias*), weakfish (*Cynoscion regalis*), American shad (*Alosa sapidissima*), striped searobin (*Prionotus evolans*), spot (*Leiostomus xanthurus*), and white perch (*Morone americana*) (Milstein and Thomas, 1976). Shore zones and estuaries provide critical migratory pathways and spawning, feeding, and nursery areas for many commercial and sport fish, as well as comprising the primary habitat for many forage fish.

Coastal waters within the Absecon Island project area support significant commercial and recreational fisheries (New Jersey Bureau of Fisheries, 1979). Commercially important species include Atlantic menhadan, silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), summer flounder (*Paralichthys dentatus*), yellowtail flounder (*Limanda ferruginea*), scup (*Stenotomus chrysops*), weakfish, butterfish (*Peprilus triacanthus*), bluefin tuna (*Thunnus thynnus*), Atlantic mackerel (*Scomber scombrus*), and American shad. Important recreational fisheries within the nearshore of the project area include striped bass (*Morone saxatilis*), black sea bass (*Centropristis striata*), weakfish, bluefish (*Pomatomus saltatrix*), tautog (Tautoga onitis), and summer flounder (New Jersey Bureau of Fisheries, 1979).

C. BIRDS AND MAMMALS

A variety of colonial nesting waterbirds occur within the vicinity of the Absecon Island project area including little blue heron (*Egretta caerulea*), tri-colored heron (*E. tricolor*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*N. violaceus*), great egret (*Casmerodius albus*), snowy egret (*E. thula*), cattle egret (*Bubulcus ibis*), glossy ibis (*Plegadis falcinellus*), great black-backed gull (*Larus marinus*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), common tern (*Sterna hirundo*), least tern (*S. antillarum*), and Forster's tern (*S. forsteri*) (Andrews, 1990). Most of the colonial nesting waterbirds inhabit and nest on islands within the back bay area and do not typically occur on the oceanfront where the project is proposed.

The Absecon Island beaches also provide important resting and feeding areas for migrating shorebirds. In 1990, the Brigantine Division of the Edwin B. Forsythe National Wildlife Refuge recorded 40,000 shorebirds in May, during the peak of the spring migration, and 20,000 shorebirds in October, during the peak of the fall migration (U.S. Fish and Wildlife Service, 1990). Common species occurring on the Absecon Island beaches and adjacent areas include ruddy turnstone (*Arenaria interpres*), willet (*Catoptrophorus semipalmatus*), red knot (*Calidris canutus*), dunlin (*Calidris alpina*), semipalmated sandpiper (*C. pusilla*), short-billed dowitcher (*Limnodromus griseus*), sanderling (*Calidris alba*), and black-bellied plover (*Pluvialis squatarola*) (New Jersey Division of Fish, Game and Wildlife, 1994). However, the Absecon Island beach currently provides little to no nesting habitat for colonial nesting waterbirds or shorebirds due to the narrow width of the beach, proximity of bulkheads and seawalls, and extensive use of the beach by humans.

A variety of waterfowl and raptors also inhabit and migrate through areas adjacent to the project area. However, other than transient occurrences, waterfowl and raptors are not likely to be present within the proposed construction areas.

Other wildlife that may be present within the project area represent species that have adapted to an urbanized, heavily developed area. These species include rock dove (*Columba livia*), house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), American crow (*Corvus brachyrhynchos*), fish crow (*Corvus ossifragus*), raccoon (*Procyon lotor*), eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), and house mouse (*Mus musculus*).

D. ENDANGERED AND THREATENED SPECIES

A review of Service records indicates that the peregrine falcon (*Falco peregrinus*), a federally listed endangered species, nests within the Absecon Island project area. The peregrine falcon has recently expanded its range and is now found nesting and hunting near urban areas. Peregrine falcons may be expected to forage for prey such as songbirds, gulls, terns, shorebirds, and wading birds within the project area. Peregrine falcons could also be expected to use other large buildings within the project area as nesting sites in the future.

The federally listed (threatened) piping plover (*Charadrius melodus*) nests within 1 mile of the proposed project site. Piping plovers nest on sandy beaches above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand.

Food for adult plovers and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

Development along the coastal shoreline for residential and commercial uses, and the subsequent stabilization of the once-shifting and dynamic beach ecosystem via seawalls, breakwaters, jetties, and groins have resulted in the destruction and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for the piping plover. The Service expects that the likelihood of piping plovers nesting on the beaches within the project area is low due to the narrow width of the beach and extensive human disturbance. However, the proposed beach nourishment may create suitable nesting areas that piping plovers may use in the future.

Other than the peregrine falcon, piping plover and an occasional transient bald eagle (*Haliaeetus leucocephalus*), no other federally listed or proposed threatened or endangered species under Service jurisdiction pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) are known to occur within the project area. However, the federally listed Kemp's Ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) are known to occur in the vicinity of the project area. Except for nesting habitat for sea turtles, principal responsibility for marine turtles and marine mammals is under the jurisdiction of the National Marine Fisheries Service (NMFS). A summary of federally listed and candidate speices in New Jersey is included as Appendix A.

VI. IDENTIFICATION OF IMPACTS AND MITIGATIVE MEASURES

A. IMPACTS

Shoreline protection efforts that include extraction of materials from offshore borrow areas, related beach nourishment operations, and installation of bulkheads and revetments may result in a variety of impacts to benthic organisms, finfish, and wildlife. Beach nourishment and renourishment activities also result in the conversion of shallow water covertypes to beach and dune covertypes.

1. Extraction from Borrow Areas

Dredging a borrow area results in the removal of sediment and organisms from the borrow area and potentially adverse water quality impacts. Upon initial beach nourishment, approximately 345 acres of benthic habitat would be adversely impacted resulting in substantial mortality of benthic organisms. Long term impacts on borrow areas include potential changes in circulation patterns affecting the pattern of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing, which can create anoxic conditions affecting benthic organism recovery. Additionally, removal of sand ridges at the proposed borrow sites may eliminate productive surf clam habitat, reducing the value and productivity of the borrow area for these organisms (Norman, pers. comm., 1996).

Most benthic organisms within the ocean's dynamic ecosystem have adapted to periodic changes in habitat that occur as a result of northeasters, hurricanes, and other storms. As a result, benthic organisms typically recolonize an area quickly, provided the habitat is still suitable. Saloman *et al.* (1982) concluded that benthic organisms recover from dredging events in approximately 1 year, with minor sedimentological changes, and a small decline in diversity and abundance within the benthic community. The Corps has also determined that recolonization of borrow areas would occur within 1 year within the project area (U.S. Army Corps of Engineers, 1996). However, disturbances within the borrow areas every 3 years for the life of the project (i.e., 50 years) would likely limit recolonization, thereby maintaining low infaunal abundance and low species diversity.

Dredging may also adversely affect water quality by increasing turbidity, changing temperature and oxygen levels, and releasing or resuspending toxins and bacteria. These factors may cause direct mortality to fish and shellfish, disrupt fish migrations, hamper fish and shellfish spawning, and reduce primary productivity. Additionally, settling of suspended sediment may result in smothering of shellfish and other benthic organisms downcurrent from the borrow area.

The type of equipment used and the time of year extraction occurs may greatly influence the nature and extent of potential adverse impacts related to dredging. For example dredging with a hydraulic dredge may reduce short-term adverse impacts on water quality, but may impact eggs, young fish, and other slow-moving organisms unable to avoid entrainment. The entrainment of sea

turtles has also been documented as an adverse impact of hydraulic dredging and hopper dredging (Wurst, pers. comm., 1996). The timing of dredging is also important in that if initiated concurrent with a period of low biological activity (November-January), it may reduce adverse impacts on fish and wildlife resources.

2. Beach Nourishment

The proposed beach nourishment and subsequant renourishment will bury infaunal organisms and result in mortality within the shallow nearshore (littoral) zone. Most of the organisms inhabiting the extremely dynamic nearshore and intertidal zones are highly mobile and adapt quickly to significant changes in abiotic factors. However, the proposed project would likely reduce infaunal abundance and species diversity despite the resiliency of the intertidal benthic fauna. Reilly and Bellis (1983) determined that recovery of macrofauna is rapid after beach nourishment activities cease; however, the recolonization community may differ considerably from the original community. Differences in grain size from the original beach and sand provided for beach nourishment may also affect the recolonization community. Based on a review of the literature, the Corps predicts that the benthic community within the littoral zone would recover in 1-2 years (U.S. Army Corps of Engineers, 1996).

The Service expects that the likelihood of piping plovers or other shorebirds to nest on the beaches within the project area is currently low due to the narrow width of the beach and extensive human disturbance. However, the proposed beach nourishment may create suitable nesting habitat that piping plovers and other beach nesting birds such as black skimmers (*Rynchops niger*), least terns, and common terns may use in future seasons. Recent beach renourishment projects (e.g., Ocean City, New Jersey) resulted in the creation of piping plover nesting habitat that did not exist prior to project construction. Unfortunately, high levels of human activity on nourished beaches often eliminates nesting success (U.S. Fish and Wildlife Service, 1988). Therefore, occurrence and nesting of federally listed or State-listed threatened or endangered species may require restrictions on some recreational activities and beach management activities (e.g., beach raking) to protect these species from adverse impacts.

3. Bulkheads and Revetments

The proposed bulkheads and associated revetments would eliminate shallow water habitat and intertidal habitat. The proposed bulkhead between Madison Avenue and Melrose Avenue would adversely impact only a small intertidal beach since the bulkhead is proposed to be aligned with existing bulkheads along Maine Avenue. However, the bulkhead and revetment proposed between Atlantic Avenue and Oriental Avenue would be located at the seaward edge of the existing boardwalk and would eliminate a relatively large area of shallow water and intertidal habitat. The proposed bulkhead may also destabilize adjacent bottom areas by reflecting wave energy and may also alter patterns of nearshore water circulation. The proposed revetment material (i.e., rough quarrystone) may provida substrate for the attachment of sessile marine organisms, which in turn may support fish and other marine life. This effect could be considered beneficial in an area with low biological activity.

B. MITIGATIVE MEASURES

1. Extraction from Borrow Areas

The Service assumes that Borrow area "D" (Brigantine Inlet) was eliminated from consideration due to its distance to the proposed project area. Borrow area "D" would be the preferred borrow source due to its apparent low density of surf clams. Since removal of material from Borrow area "D" is apparently not feasible, the Service concurs with the Corps proposed use of Borrow area "A" (Absecon Inlet) as the preferred borrow source. Compared with other potential borrow areas, Borrow area "A" had the lowest benthic organism abundance, lowest species diversity, and lowest surf clam abundance. However, Borrow area "A" is still considered to be a productive area for surf clams (Norman, pers. comm., 1996). To ensure that impacts to surf clams are minimized to the extent possible, the Service recommends that the Corps consult with the New Jersey Bureau of Shellfisheries.

In order to minimize repeated impacts on benthic organisms within the borrow area, the Service recommends that the Corps conduct each renourishment dredging phase in a limited area of the borrow area and alternate locations for each subsequent renourishment cycle. This concept of rotational dredging minimizes frequent, repeated disturbance of a particular area, thereby allowing recolonization of benthic organisms to occur over a longer period of time.

If previously identified borrow areas other than Borrow area "A" are required for subsequent renourishment cycles, the Corps proposes to initiate update surveys to determine current benthic population characteristics. In addition, the Corps proposes to implement a benthic monitoring program, concurrent with periodic maintenance activities, to document project-related impacts and aid in avoiding impacts to sensitive areas during the periodic maintenance activities. The Service recommends that the Corps provide the federal resource agencies (e.g., Service and NMFS) copies of the borrow area update surveys, the benthic monitoring program, and results of the benthic monitoring program.

In order to avoid anoxic conditions in the borrow area, which would inhibit recolonization of benthic organisms, the Service recommends avoiding the creation of excessively deep, poorly flushed borrow sites. The Service also recommends dredging during the period of lowest biological activity (November to January) to minimize impacts on benthic organisms.

Typically hydraulic-pipeline dredging is preferred over hopper dredging by the Service because hydraulic dredging minimizes turbidity. Additionally, hydraulic-pipeline dredging minimizes the potential entrainment of federally listed sea turtles (Wurst, pers. comm., 1996). Therefore, the Service recommends the use of hydraulic-pipeline dredging over hopper dredging. The NMFS should be contacted regarding potential impacts on federally listed species (under its jurisdiction) as a result of the proposed project.

2. Beach Nourishment

Beach nourishment and subsequent renourishment would create approximately 201 acres of new beach area along Absecon Island. Much of the area created and the existing beach area would be considered upland. It is assumed that the Corps would obtain an easement for the project area for the project life (e.g., 50 years) in order to complete renourishment activities. However, it is unclear what type of easement would exist after the project is completed. In order to prevent residential or commercial development within the project area or adjacent beach area, the Service recommends that the Corps obtain a perpetual deed restriction or conservation easement for the newly created beach and adjacent beach areas.

Recent beach renourishment projects (e.g., Ocean City, New Jersey) resulted in the creation of piping plover nesting habitat that did not exist prior to project construction. Construction of the proposed project may create suitable nesting habitat for piping plovers, shorebirds, and colonial nesting waterbirds. Further coordination from the Corps would be necessary in the event that piping plovers nest on the beaches within the project area before beach nourishment is completed. Further coordination could result in seasonal restrictions on construction activities being imposed if piping plovers are identified on project area beaches. Should piping plovers use these beaches, the Service will recommend that protective zones be established in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (Guidelines) dated April 15, 1994 (Appendix B). Establishment of protective zones would be coordinated with the appropriate municipalities by the New Jersey Division of Fish, Game and Wildlife, Endangered and Nongame Species Program (ENSP). The Corps would be responsible for providing materials (e.g., fencing, signs) or funds for materials for such protective zones. Additionally, further consultation with the Service pursuant to Section 7 of the Endangered Species Act would be required by the Corps for each renourishment phase of the project for the project life (e.g., 50 years) on beaches where piping plovers are documented. Further consultation may result in seasonal restrictions of construction activities.

In order to prevent future misunderstanding regarding the protection of piping plovers, the Service recommends that the Corps notify each municipality on Absecon Island individually (e.g., Atlantic City, Ventnor, Margate, and Longport) regarding the potential for recreational activity and beach management (e.g., beach raking) restrictions if piping plovers occur on the beaches of Absecon Island. In addition, each municipality should receive a copy of the above-mentioned Guidelines to become familiar with potential recreational activity and beach management restrictions. The purpose of notifying municipalities in advance is to clarify the responsibilities of the municipalities that are benefiting from the proposed federal project. If municipalities are unwilling to cooperate with the Corps and the Service regarding piping plover management, the Corps should consider eliminating the municipality from the proposed project.

In the event that beach nesting birds do nest on Absecon Island, the Service recommends that the Corps develop educational materials (e.g., brochures, informational signs) or provide funds for public education and outreach. Development of informational materials would educate beach users about beach nesting birds; thereby reducing disturbance to nesting areas. Public education would also promote public support for protecting beach nesting birds.

Finally, the Service recommends that the Corps develop and implement a shorebird monitoring program in cooperation with the Service that monitors the use of the proposed nourished beaches for shorebirds, in particular piping plovers. This shorebird monitoring program should be designed to identify and report use of the project area beaches by shorebirds, particularly the piping plover, for the life of the project (e.g., 50 years). The Service recommends that the Corps submit the proposed shorebird monitoring program to the Service for review and comment.

3. Bulkheads and Revetments

The proposed bulkhead between Atlantic Avenue and Oriental Avenue along the seaward edge of the existing boardwalk would result in the loss of a relatively large area of shallow water and intertidal habitat. The Corps determined that the proposed bulkhead was necessary at the seaward edge of the existing boardwalk in order to protect the existing boardwalk. Relocation of the boardwalk landward was considered in the alternatives analysis, but was eliminated from further consideration because costs outweighed the benefits. However, the boardwalk relocation alternative was not considered in combination with construction of a bulkhead. Relocating the boardwalk landward and constructing the bulkhead on the seaward side of the boardwalk would eliminate impacts on shallow water habitat and would likely be economically feasible since benefits (total annualized damages: $616,000) would outweigh the costs (preliminary annualized costs: $195,000) based on figures presented in the Corps alternatives analysis (U.S. Army Corps of Engineers, 1996). Therefore, the Service recommends that the Corps relocate the boardwalk landward between Atlantic Avenue and Oriental Avenue and construct a bulkhead and revetment on the seaward side of the boardwalk, in order to minimize impacts on shallow water habitat.

VII. DATA GAPS

Results from the above-mentioned benthic update surveys for alternative borrow areas and the benthic monitoring program remain unknown. Results from the benthic monitoring program will be informative, since the long-term effects on benthic communities as a result of beach nourishment and renourishment are not well understood.

The proposed project could create habitat for shorebirds, colonial nesting waterbirds, and the federally listed threatened piping plover. If these birds begin using the project area in the future, an assessment of potential adverse impacts and appropriate mitigative measures would need to be conducted. The recommended shorebird monitoring program will provide the Corps and the Service with the results necessary to assess future impacts on shorebirds, particularly the piping plover.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The proposed project area is located in a highly-developed region of New Jersey that currently supports limited fish and wildlife resources. Overall, implementation of the Absecon Island project would enhance fish and wildlife habitat within the project area. Enhancement would be accomplished by creating a wider beach and establishing a dune complex, to include 91 acres of planted dune grass. However, by creating a wider beach and a dune complex, the possibility of colonial nesting waterbird, piping plover and other shorebird use of the project area increases. Potential use of the project area beaches by humans and the above-mentioned birds may conflict. Monitoring and appropriate management would be required to minimize such conflicts.

It is the view of the Service that project-related adverse impacts to fish and wildlife could be minimized by incorporating the following recommendations into the final project design.

1. Consult with the New Jersey Bureau of Shellfisheries to minimize impacts on surf clams at Borrow area "A."

2. Conduct each renourishment dredging phase in a limited area of Borrow area "A" and alternate locations for each subsequent renourishment cycle (rotational dredging).

3. Provide the federal resource agencies (e.g., Service and NMFS) with copies of borrow area update surveys, the benthic monitoring program, and results of the benthic monitoring program.

4. Avoid creating excessively deep, poorly flushed borrow areas and schedule dredging during the period of lowest biological activity (November to January) to minimize impacts on benthic organisms.

5. Use a hydraulic-pipeline dredging method and contact the NMFS regarding potential impacts on federally listed threatened or endangered species under its jurisdiction.

6. Obtain a perpetual deed restriction or conservation easement for the newly created beach and adjacent beach areas.

1. The Corps will continue to coordinate with the New Jersey Bureau of Shellfisheries to minimize impacts to surf clams within the proposed borrow areas. Steps already taken by the Corps to minimize these impacts include; using the Absecon Inlet borrow area (which has the lowest surf clam density of the proposed borrow areas), reducing the amount of surface acres of benthic habitat impacted by reducing the size of the Absecon Inlet borrow area, and planning to use the Absecon Inlet borrow area for renourishment cycles to avoid impacting borrow areas with higher surf clam densities.

2. In order to minimize the impacts of renourishment on the benthic community the Corps will limit the size of the borrow area used during renourishment as much as possible. Also, the Corps will alternate the location of sand removal during subsequent nourishment cycles, providing that the deposition of sand within the borrow area allows for such a rotation.

3. Copies of all benthic survey results, as well as the proposed monitoring program will be provided to the appropriate state and Federal agencies.

4. For the purposes of this project, the Absecon Inlet borrow area was designed to provide the required amount of sand for beachfill, while impacting the smallest amount of surface area possible. This was done primarily to minimize impacts to surf clams and other benthic organisms. During the dredging of sand from the inlet it will be necessary to excavate sand to a depth approximately 15 - 20 feet below its current elevation. Despite the depth of excavation required, the Corps does not believe the dredging will create excessively deep, poorly flushed borrow areas. Due to the fact that the proposed borrow area is located within an inlet, large quantities of water are moved through the area on a daily basis. In addition to providing the necessary water movement and flushing, it is believed that sand will be readily replaced at the site through the natural forces acting on the inlet.

The Corps will make every attempt to work within this recommended seasonal window. However, due to the size of this job, construction will most likely take several months, which may preclude the construction taking place only in the months of November to January. In addition, storms and severe weather conditions which are typical of this time of year may make construction during this time very challenging and possibly dangerous.

5. The dredging method used for the proposed project is left to the discretion of the contractor hired to complete the construction. If a hopper dredge is used, the appropriate precautions will be taken to address potential impacts to protected sea turtles. The Corps is currently engaged in formal Section 7 consultation with the NMFS. This consultation covers all proposed projects within the Philadelphia District. The Corps will follow the NMFS recommendations that result from this consultation.

7. Coordinate with the Service prior to initial beach nourishment to ensure that piping plovers do not occur on the project area beaches.

8. If piping plovers use these beaches after initial beach nourishment, establish protective zones in accordance with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act." The Corps would be responsible for providing materials (e.g., fencing, signs) or funds for materials for such protective zones.

9. Consult with the Service pursuant to Section 7 of the Endangered Species Act for each renourishment phase of the project for the project life (e.g., 50 years) on beaches where piping plovers are documented.

10. Notify each municipality on Absecon Island individually (e.g., Atlantic City, Ventnor, Margate, and Longport) regarding the potential for recreational activity and beach management (e.g., beach raking) restrictions if piping plovers occur on the beaches of Absecon Island.

In addition, each municipality should receive a copy of the above-mentioned Guidelines to become familiar with potential recreational activity and beach management restrictions.

11. In the event that beach nesting birds do nest on Absecon Island, develop educational materials or provide funds for public education and outreach to inform the public about beach nesting birds and promote public support for these species.

12. Develop and implement a shorebird monitoring program in cooperation with the Service that monitors the use of the proposed nourished beaches for shorebirds, in particular piping plovers. Additionally, submit the proposed shorebird monitoring program to the Service for review and comment.

13. Relocate the boardwalk landward between Atlantic Avenue and Oriental Avenue and construct a bulkhead and revetment on the seaward side of the boardwalk, in order to minimize impacts on shallow water habitat.

6. Concur. The sponsor will be required to obtain petual beac nourishment and dune easements on all lands within the project area. Following completion of the project (50 yrs.), these easements will remain in effect for perpetuity.

7. The Corps will continue to coordinate with the Service and the NJDEP to ensure that piping plovers do not occur on project area beaches prior to construction.

8. The Corps will work closely with state and Federal agencies to avoid impacts to piping plovers during all construction and renourishment activities. The beach created through the construction and renourishment activities would continue to be under the jurisdiction of the State of New Jersey. The NJDEP currently has an extensive piping plover protection program which includes counting birds and nests, as well as providing fencing, signs and other protective measures. We envision that this program would continue for the Absecon Island project area, as it has in the Ocean City project area.

9. The Corps will coordinate with the Service and the state Endangered and Nongame Species Program prior to each renourishment phase. This coordination will serve to update current information regarding the presence of piping plovers and other threatened and endangered species within the project area.

10. The Corps will provide the requested information regarding piping plovers to all relevant cities and municipalities within the project area. In addition, the Corps will make sure that these areas are aware of possible restrictions that would be put in place in the event of piping plover nesting in the study area.

11. The Corps will work with state and Federal endangered species programs to ensure public awareness in the event that piping plovers are found nesting within the project area.

12. The New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Endangered and Nongame Species Program has an extensive monitoring program for piping plovers and other threatened and endangered species already in place. The Corps frequently coordinates efforts with this section of NJDEP and is kept fully aware of the presence of nesting plovers along the New Jersey Coastline. The Corps will continue to coordinate with the Endangered and Nongame Species Program to avoid any impacts to these and other threatened or endangered species.

13. The Corps' analysis of relocating the boardwalk to a more landward position did include the consideration of the construction of the bulkhead as well. However, relocating the boardwalk in addition to the placement of the bulkhead was not economically feasible. Construction of the bulkhead in the Corps' recommended location requires backfilling to ensure the structural integrity of the bulkhead. This would result in the filling of approximately 0.3 acres of intertidal beach water area. This "beach", however, is principally comprised of remnant building rubble and is widely regarded by the sponsor and local community as being a visual blight with marginal environmental value and no recreational or other public use (refer to figure 23 on pg 98 of report). In addition, the shoreline in this area has been receding, with the proposed bulkhead location actually landward of the State's 1986 MHW line. The existing shoreline is expected to continue to erode, eventually requiring stabilization at a more landward position in the future. Therefore, the construction of the bulkhead at the recommended location would stabilize the shoreline along an area where it would ultimately be lost anyway. The backfill required for construction of the bulkhead would also improve the aesthetics of the area and create additional public use opportunities.

4. Integrate our "geotube" activities and efforts within the scope of the project to assure a comprehensive approach to the treatment of same.

We would be please to have our Engineer, staff and consultants discuss the above request at further length with your office as the project design develops and in support of your project activities.

Sincerely,

James Whelan
MAYOR

JW/jd
cc: William Rafferty, PE
Robert Levy, Jr., Director - Emergency Management
Robert C. Mainberger

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

JUN 20 1996

Robert L. Callegari, Chief
Planning Division
U.S. Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Class: EC-2

Dear Mr. Callegari:

The Environmental Protection Agency (EPA) has reviewed the draft environmental impact statement (EIS) for the Absecon Island Interim Feasibility Study from Brigantine Inlet to Great Egg Harbor Inlet, Atlantic County, New Jersey. This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609, PL 91-604 12(a), 84 Stat. 1709), and the National Environmental Policy Act.

The proposed project involves the use of beach nourishment, dune stabilization, and bulkhead construction to reduce the potential for storm damage to properties on Absecon Island. Several structural and non-structural alternatives are considered, including seawalls, breakwaters, groins, flood insurance, development regulations, evacuation, and no action. The preferred alternative involves utilizing sand obtained from three borrow areas to restore berms and dunes along the Island's ocean frontage; beach nourishment will be augmented by dune grass, sand fences, and pedestrian and vehicular access ramps. The proposed plan also includes construction of two bulkheads along the south side on Absecon Inlet. Based on our review, we offer the following comments.

1. The proposed project calls for the initial placement of approximately 6.2 million cubic yards of sand; subsequent nourishment with approximately 1.7 million cubic yards will be provided every three years for 50 years. The draft EIS, however, does not sufficiently document the need to nourish the beach on a fixed routine basis, nor does it provide a plan to be followed in the event that nourishment is not required. EPA is concerned that the proposed maintenance plan may exceed the nourishment needs within the project area, potentially causing unnecessary impacts to the benthic community and water quality. With this in mind, we suggest that the final EIS provide beach nourishment plans that are related to an appropriate maintenance schedule, rather than a pre-established three year schedule.

1. The nourishment plan proposed for this project, 1.7 million cubic yards of material every three years for 50 years, was developed primarily for the purposes of cost estimating. In order for a project to proceed through the Feasibility Phase, it is necessary to develop detailed project cost estimates for the 50 year project life. A three year nourishment cycle represents expected nourishment requirements. Once initial construction has been done, beach surveys will be conducted yearly to measure and record the amount and location of sand on the beach. From these surveys it will be determined when, where, and how much sand is needed along the length of the project. These surveys enable the nourishment to be completed only when and where it is needed, therefore saving time and money, as well as minimizing environmental impacts.

2. The preferred alternative also includes construction of two timber sheet-pile bulkheads and placement of a quarry stone revetment along the south side on Absecon Inlet. We understand that the proposed bulkheads would follow a previously disturbed older bulkhead alignment. When bulkheads are used in areas such as this, where there is significant wave action, they may accelerate beach erosion. Accordingly we recommend that the final EIS evaluate alternative shore stabilization structures.

3. We understand that this is one of several proposed and on-going U.S. Army Corps of Engineers (ACE) erosion and storm damage protection projects in this area, all of which involve beach nourishment with sand dredged from offshore borrow areas. EPA is concerned that the implementation of these projects could result in adverse cumulative impacts. Unfortunately, a comprehensive evaluation of the cumulative impacts of all of these projects has yet to be performed. Accordingly, the ACE should prepare a comprehensive cumulative impacts analysis (possibly through a programmatic EIS) for all of these projects prior to initiation of construction. At a minimum, the evaluation should address impacts to water quality, terrestrial and aquatic ecosystems, including benthic and back bay habitats, and endangered species.

In conclusion, based on our review and in accordance with EPA policy, we have rated this draft EIS as EC-2, indicating that we have environmental concerns (EC) about impacts to benthic communities and water quality, and the potential cumulative impacts associated with this and other erosion/storm damage protection projects in New Jersey. Accordingly, additional information (2), as outlined in this letter, should be presented in the final EIS to address these issues.

Should you have any questions concerning this letter, please contact Deborah Freeman of my staff at (212) 637-3514.

Sincerely yours,

Robert W. Hargrove, Chief
Environmental Impacts Branch

2. Nine other structural and non-structural alternatives were reviewed during the formulation process associated with this study (summarized in Tables 30, 31 and 35 of the main report). The bulkheads with toe revetment were concluded to be the most effective and economical feature to reduce the damage potential for this portion of the inlet shoreline. The bulkhead is also consistent with virtually all of the other existing structural features along Absecon Inlet.

The effects of seawalls/bulkheads on coastal processes has seen increased research over the past decade including extensive field monitoring of structured versus non-structured sites and laboratory investigation of beach/seawall interaction (Griggs, et al. 1996; Kraus and McDougal, 1996; U.S. Army Corps of Engineers, 1995; Basco, et al. 1994; Hughes and Fowler, 1990). Although beach/seawall interactions must be evaluated on a site specific basis, preliminary results of the above mentioned research is casting doubt on previous theories indicating extensive profile scour due to seawalls. When comparing profiles with seawalls versus adjacent unstructured control beaches over monitoring periods, long-term adverse effects due to the seawalls are not being observed (U.S. Army Corps of Engineers, 1995).

Additionally, toe protection in the form of a quarrystone revetment will be placed along the proposed vertical bulkhead at Absecon Inlet, thus further reducing wave action and scour potential at the base of the bulkhead.

3. At this time, a comprehensive cumulative impacts analysis is not within the scope of any of the Corps' proposed or on-going erosion and storm damage protection projects. The Corps does believe however that concerns regarding the issue of cumulative impacts associated with erosion and storm damage protection projects along the New Jersey coastline are valid. All proposed or on-going projects in this area consist of post construction surveys to evaluate impacts to benthic and fisheries habitat. These ongoing surveys, and the results they provide, help to track population trends and habitat value. These surveys are, and will continue to be, valuable indicators of impacts associated with specific projects, as well as any cumulative impacts resulting from the implementation of numerous projects.

U.S. Department of Transportation
United States Coast Guard

Commanding Officer
U.S. Coast Guard
Civil Engineering Unit

1240 E. 9th Street
Cleveland, OH 44199-2060
(216)-522-3934

11000
MAY 22 1996

Robert Callegari
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building 100 Penn Square East
Philadelphia, PA 19107-3390

Dear Mr. Callegari

We have reviewed your May 1, 1996 letter that contained a Beach Restoration Draft Feasibility Report and Environmental Assessment (EA) for several beaches in New Jersey.

This project should have no adverse affects on Coast Guard facilities or operations in the area. The project should provide protection to our lighthouses and stations.

Thank you for the opportunity to comment on your project and EA. Should you have any questions please call Gary Nelson at (216) 522-3934 ext 635.

Sincerely,

R A Koehler

R. A. KOEHLER
Commander, U.S. Coast Guard

Copy: Maintenance and Logistics Command Atlantic (s)

1. **No response required.**

UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

June 7, 1996

Mr. Robert L. Callegari
Chief, Planning Division
DOA, Philadelphia District, COE
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

Dear Mr. Callegari:

Enclosed are comments on the Draft Environmental Impact Statement for Federal Participation in a Storm Damage Reduction Project for the Communities of Atlantic City, Ventnor, Margate and Longport, New Jersey. We hope our comments will assist you. Thank you for giving us an opportunity to review this document.

Sincerely,

Donna S. Wieting
Acting Director
Ecology and Conservation Office

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
National Geodetic Survey
Silver Spring, Maryland 20910-3282

MEMORANDUM FOR: Donna Wieting [illegible]
Acting Director, Ecology and Conservation Office

FROM: Captain Lewis A. Lapine, NOAA
Director, National Geodetic Survey

SUBJECT: DEIS-9605-04--Federal Participation in a Storm Damage Reduction Project for the Communities of Atlantic City, Ventnor, Margate and Longport, New Jersey

The subject statement has been reviewed within the areas of the National Geodetic Survey's (NGS) responsibility and expertise and in terms of the impact of the proposed actions on NGS activities and projects.

All available geodetic control information about horizontal and vertical geodetic control monuments in the subject area is contained on the NGS home page at the following Internet World Wide Web address: http://www.ngs.noaa.gov. After entering the NGS home page, please access the topic "NGS Products and Services" and then access the menu item "NGS Products." This menu item will allow you to directly access geodetic control monument information from the NGS data base for the subject area project. This information should be reviewed for identifying the location and designation of any geodetic control monuments that may be affected by the proposed project.

1. If there are any planned activities which will disturb or destroy these monuments, NGS requires not less than 90 days' notification in advance of such activities in order to plan for their relocation. NGS recommends that funding for this project include the cost of any relocation(s) required.

For further information about these monuments, please contact John Spencer; SSMC3, NOAA, N/NGS; 1315 East West Highway; Silver Spring, Maryland 20910; telephone: 301-713-3169; fax: 301-713-4175.

With regard to the U.S. coastal zone, the selected ocean front plans for the Absecon Island study area proposes widening the area using fill from the designated offshore borrow sites beach berm by 200 feet.

2. The National Ocean Service requests a copy of the U.S. Army Corps of Engineers "as built" plans, upon completion of this project, so that any related shoreline changes can be accurately detailed on future editions of NOS nautical chart 12316. Please send plans to: Howard Danley, NOAA, Office of Coast Survey, N/CS28, 1315 East West Highway, Silver Spring, Maryland 20910.

1. The proposed storm damage reduction project will not disturb or destroy any geodetic control monuments.

2. A copy of the "as built" plans will be forwarded to this office upon completion of the project.

State of New Jersey
Department of Environmental Protection
DIVISION OF PARKS AND FORESTRY
HISTORIC PRESERVATION OFFICE
CN-404
TRENTON, N.J. 08625-0404
TEL: (609) 292-2023
FAX: (609) 984-0578

HPO-F96-70
June 7, 1996

Mr. Robert L. Callegari
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Attn: Michael Swanda

Dear Mr. Callegari:

1. Thank you for having provided the opportunity to review the Draft Feasibility Report and the Draft EIS for the Absecon Island Beach Nourishment Project, Brigantine Inlet to Great Egg Harbor Inlet. I do not have any comments on the drafts except one minor comment. The exclusion areas discussed on page 42 reference Figure 51; the exclusion areas are actually illustrated on Figure 54.

The Office looks forward to receiving the final cultural resource survey report for the project.

Thank you for providing this opportunity for review and consultation. If you have any questions, please do not hesitate to contact Deborah Fimbel, staff reviewer for this project.

Sincerely,

Dorothy P. Guzzo
Deputy State Historic
Preservation Officer

DPG:DRF
C:\PW\wd\106\961481

1. Noted. This change was made in the final report.

State of New Jersey
Department of Environmental Protection
Land Use Regulation Program
CN 401
Trenton, New Jersey 08625
Fax # (609) 292-8115

Robert C. Shinn, Jr.
Commissioner

1996

Mr. Frank Cianfrani
Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania

Re: Request For Extension of Time
Federal Consistency Review
Case File #0000-96-0009.1
Absecon Island Dredging/Beach Fill

Dear Mr. Cianfrani:

1. The Land Use Regulation Program is in the process of reviewing the Federal Consistency application for the above referenced project and is requesting an extension of time from your agency.

The case was received on May 3, 1996 and the Federal Consistency review as Type 2 category is 45 calendar days of review time or June 16, 1996.

I understand the extension of time issued by your agency is for a maximum of 15 additional calendar days or June 30, 1996.

Please confirm that this extension has been issued.

Sincerely Yours,

Karl Braun, Section Chief
Bureau of Coastal Regulation

1. **The requested extension was granted.**

State of New Jersey
Department of Environmental Protection
Land Use Regulation Program
CN 401
Trenton, NJ 08625
Fax # (609) 292-8115

June 28, 1996

Mr. Robert L. Callegari
Planning Division
Department of the Army
Philadelphia District
Philadelphia, Pennsylvania 19107

Re: Water Quality Certification and
Federal Consistency Statement Request
Absecon Island Dredging/Beach Fill Study
Case File # 0000-96-0002.1
Atlantic City, Ventnor, Margate and Longport
Atlantic County

Dear Mr. Callegari,

The New Jersey Department of Environmental Protection, Land Use Regulation Program, acting under Section 307 of the Federal Coastal Zone Management Act (P.L. 92-583) as amended, has reviewed and determined that the above project is not consistent with New Jersey's Rules on Coastal Zone Management N.J.A.C. 7:7E as amended to July 18, 1994 and the applicable Rules guiding issuance of a Section 401 Water Quality Certificate.

This finding was made with reference to the Rules on Coastal Zone Management, specifically: Surf Clam Areas (N.J.A.C. 7:7E-3.3.,Beaches(N.J.A.C.7:7E-3.22), Structural Shore Protection (N.J.A.C.7:7E-7.11(e)) and Filling (N.J.A.C.7E-4.2).

PROJECT DESCRIPTION:

The project is intended to replenish and maintain the existing beach and dune areas for the coastal communities of Atlantic City, Ventnor, Margate and Longport. The project includes the dredging and placement of approximately 6.2 million cubic yards of sand initially with a periodic replenishment of 1.67 million cubic yards of dredged sand every 3 years over a 50 year project life.

1. Since the receipt of this letter, a meeting has taken place between the State of New Jersey and the Philadelphia District to discuss the issues raised in this letter. As a result of this letter and the meeting, the Corps prepared a response letter, which can be found in this section immediately following the comments from NJDEP. Coordination will continue between the Corps and NJDEP until all these issues have been resolved.

The beachfill will create a varied 100' to 200' sand berm with a graduated side slope of 1:5. Over 91 acres of planted dune area will contain 64,000 linear feet of sand fencing and vehicle ramps.

Two sections of timber bulkhead with stone revetments along Absecon Inlet in Atlantic City are included in this proposal.

Three sand borrow areas are proposed off of Absecon Island including the Absecon Inlet shoal, the Atlantic City shoal and the ebb shoal opposite the Great Egg Harbor River Inlet.

The project is described in the "Absecon Island Interim Feasibility Study" Volume 1 dated April 1996.

The Program's determination that the above described project is inconsistent with New Jersey's Coastal Zone Management Rules is based on the following review:

Surf Clam Areas N.J.A.C. 7:7E 3.3

Development which would result in the destruction, condemnation or contamination of surf clam areas is prohibited. Development within surf clam areas is conditionally acceptable only if the development is of national security interest and no prudent and feasible alternative sites exist.

As noted by memorandum dated June 13, 1996 from the Bureau of Shellfisheries, the dredging component of the project would destroy commercially viable beds of Surf Clams and be inconsistent with this Rule.

The Program notes that the report referenced that several sites were identified as suitable because of the results of vibracore analysis. Vibracore analysis was performed for fifteen sites and only three sites were considered suitable. Because the three sites selected conflict with this Rule, other sites including the areas initially rejected should be brought back in for re- evaluation and data, including location, submitted to justify their rejection. In addition, the Program requests that if not already evaluated, the shoal area at the mouth of the Great Egg Harbor Inlet should be studied.

The Program also requires an explanation of the reason for the differences in beach profile width (200' for Atlantic City and 100' for the balance of projected areas). The beach width must be justified as a narrower beach would significantly reduce disturbance of existing benthic resources.

Beaches(N.J.A.C.7:7E-3.22)

Development is prohibited on beaches except for development that has no prudent alternative and will not create an adverse impact to the natural functioning of the beach system.

The intention to provide a timber bulkhead and stone revetment between Atlantic and Oriental Avenues would eliminate an existing beach area which is prohibited unless there are no alternatives and no adverse impacts to the beach system. Alternatives to placing the timber bulkhead in a position to eliminate the beach must be presented in order for this Rule to be met.

The Program also notes that the exact positioning of the proposed new bulkhead at this location was vague and needs greater detailing to evaluate more fully when the alternative alignments are resubmitted for re-review by the Program. The position of the proposed new bulkhead along Maine Avenue should also be detailed in order to enable a finding of consistency to be made.

The Feasibility Report references public access through the dunes via skewed paths and mentions dune walkovers as well. Further detail is required to explain the method of public access through or over the dunes to determine whether the Dune rule (7:7E-3.16 and 3A) is met.

Filling (N.J.A.C.7:7E-4.2)

The intention to bulkhead a portion of the Absecon Inlet from Atlantic to Oriental Avenues will fill a portion of water area which could be avoided by moving the point of stabilization and extent of filling to at or above the spring high water line.

Because alternatives to filling this shoreline were not presented, the Program finds that this Rule has not been met.

The findings under the Beach and Surf Clam Area Rules are reinforced by the Structural Shore Protection Rule (7:7E-7.11(e)).

The project as proposed is inconsistent with New Jersey's Rules on Coastal Zone Management (N.J.A.C. 7:7E).

The Program has also received comments from the Bureau of Marine Fisheries dated June 19, 1996 which raise several concerns about the project which should be discussed between all interested agencies. The Program notes that review comments offered by the Bureaus of Shellfisheries and Marine Fisheries appear to conflict with regard to use of the Absecon Inlet borrow site, based on the different resources they are charged with protecting. I have attached both of these documents for your response.

In an effort to encourage the selection of suitable beach material sites and develop an approvable project, the Program offers to coordinate a meeting between representatives of Fish, Game and Wildlife, the Land Use Regulation Program and your Planning Division as soon as possible. Please contact Karl Braun at (609) 292-8262 to initiate such discussions.

Sincerely Yours,

Richard Kropp, Director
Land Use Regulation Program

enclosures
c: A. Didun, Fish, Game and Wildlife
J. Normant, Fish, Game and Wildlife
Helen Farr, NOAA

State of New Jersey
Department of Environmental Protection
Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625-0400
Robert McDowell
Director

MEMORANDUM

TO: Andy Didun
Division of Fish, Game & Wildlife

FROM: Jeffrey C. Normant, Senior Biologist
Bureau of Shellfisheries

DATE: June 13, 1996

SUBJECT: Brigantine Inlet to Great Egg Harbor Bay Inlet, Absecon Island Interim Feasibility Study.

This is a response to the proposed borrow sites A, B and C off Absecon Island.

The Bureau of Shellfisheries annual Surf Clam Inventoty project has revealed commercially viable Surf Clam (Spisula solidissima) stocks in the waters offshore of Absecon Island. This area has historically supported commercial surf clam harvest activities. In addition, data collected by Versar Inc. on October 25, 1995 at the proposed borrow sites corroborates with data collected by the Bureau.

Since the proposed borrow sites are located within productive surf clam habitat, the proposed sand-mining activities of these borrow sites would be inconsistent with the Rules on Coastal Zone Management regarding surf clam areas (N.J.A.C. 7:7E-3.3) due to the following policies:

1. Development which would result in the destruction, condemnation, or contamination of surf clam areas is prohibited.

2. Development within surf clam areas is conditionally acceptable only if the development is of national security interest and no prudent and feasible alternative sites exist.

c Karl Braun
Bill Andrews

State of New Jersey
Department of Environmental Protection
Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625-0400
Robert McDowell
Director

MEMORANDUM

TO: Andy Didun
FG&W, Office of Environmental Review

FROM: Bill Andrews
Bureau of Marine Fisheries

DATE: June 19, 1996

SUBJECT: Absecon Island Interim Feasibility Study

I have reviewed the above subject study and Environmental Impact Statement prepared by the U.S. Army Corps of Engineers, Philadelphia District (COE). The study recommends beach nourishment that will result in a 200' wide berm in Atlantic City and a 100' wide berm in Ventnor, Margate and Longport. Three offshore borrow areas were identified as sources of material. The preferred plan also consists of a timber sheet-pile bulkhead and stone revetment for Absecon Inlet. The following recommendations are offered:

1) The berm width for Atlantic City should be reduced to 100' which is consistent with COE shore protection projects in Monmouth and Cape May counties and the Ventor to Longport reach. This would significantly reduce project impacts to fishery resources by reducing the need for dredge materials and beach fill while offering the same protection afforded other communities.

2) Dredging activities should be restricted to the Absecon Inlet borrow area.

3) Borrow pit design should preserve ocean bottom topography by restricting dredging activities to broad areas with relative shallow and uniform depths to promote rapid recolonization of biota.

4) Borrow areas should not impact upon shipwrecks or natural bathmetric features which have a demonstrated history of supporting a significant level of recreational or commercial fishing activity.

5) The post-construction project monitoring plan which consists of sediment sampling of the beach and borrow areas should also incorporate post-construction benthic macroinvertebrate assessments that evaluate the recovery rates and develop mitigation measures if necessary. Post-construction studies and renourishment plans should be provided to resource management agencies for review and comment prior to all renourishment activities.

BA:pa102

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

Planning Division

JUL 31 1996

Richard Kropp, Director
NJDEP, Land Use Regulation Program
CN 401
Trenton, New Jersey 08625

Dear Mr. Kropp:

The Corps of Engineers, Philadelphia District (COE) is responding to your letter dated June 28, 1996, which has denied Water Quality Certification and Federal Coastal Zone Consistency for the COE's proposed beachfill project for Absecon Island, NJ as outlined in our Draft Absecon Island Interim Feasibility report and Environmental Impact Statement.

A follow up meeting occurred on July 19, 1996 and was attended by representatives from both the COE and NJDEP (attachment 1). Based on both the original letter, and discussions at the July 19 and subsequent meetings internal to NJDEP, we have provided the enclosed additional information for re-review for Coastal Zone Consistency.

The State of New Jersey, acting through the NJDEP, has embarked on a longterm partnership with the Corps, as the non-Federal sponsor required by our planning process. The New Jersey Shore Protection Study provides the comprehensive Federal authority resulting in virtually the entire ocean shoreline of New Jersey currently under study at various stages of our process. The state's considerable efforts to procure a stable funding source for shore protection, enabled NJDEP to enter into our cost-shared planning, and ultimately, construction program. In most cases, the most cost effective, and socially and environmentally preferred means of oceanfront shore protection has been provided through a program of beach nourishment. The Absecon Island project, as well as all other ongoing studies have extremely strong support from the Federal and state delegations as well as the communities in need of additional shore protection.

Our respective agencies are committed to develop well planned and designed shore protection projects which minimize adverse impacts to the environment. A comprehensive program such as this is much preferred to the piecemeal, and often ineffectual shore protection efforts undertaken on a localized scale. To date, a sizable investment of millions of dollars of state and Federal funds has already taken place and is expected to continue

as these studies come to conclusion. The issue regarding offshore sand mining for beachfill and surf clam impacts is likely to be a recurrent problem unless we can resolve the conflict in usage of these competing activities. My staff will continue to work closely with those within NJDEP to resolve additional concerns as this and future projects move ahead. It should be noted that our process enables us to modify future activities if and when conditions warrant.

It is our understanding that a letter from NJDEP Assistant Commissioner Jim Hall's office will be forthcoming under separate cover regarding the surf clam issue as well. Based on the additional information provided and consideration of our proposals, reconsideration for consistency with New Jersey's rules on Coastal Zone Management (NJAC 7:7E) and issuance of a Section 401 Water Quality Certificate are requested. Further questions or clarification of information contained herein, can be directed to Doug Gaffney, Project Manager, at (215) 656-6574.

Sincerely,

Robert L. Callegari
Chief, Planning Division

Enclosure
Attachments (6)

ABSECON ISLAND SHORE PROTECTION PROJECT
ADDITIONAL INFORMATION IN SUPPORT OF
COASTAL ZONE CONSISTENCY

BORROW SITE REQUIREMENTS AND SURF CLAM IMPACTS

The use of the three identified offshore borrow sites for sand extraction for the proposed beachfill project was deemed inconsistent with NJAC 7:7E-3.3 because of the impact dredging would have on indigenous surf clam populations. Further information on these and alternative locations was requested. In addition, consideration of a smaller berm width along Atlantic City was suggested since it would require less quantity of sand to construct.

Borrow Sites

The three potential borrow sites identified by the COE (see attachment 2), were the result of a significant technical, cultural (shipwreck) and benthic environmental analysis. These studies are routine to our planning process which identifies sufficient sand resources to construct a project while minimizing adverse environmental impacts. The sites identified, particularly site A in and adjacent to Absecon Inlet, were repeatedly modified and reduced in areal extent throughout the study to minimize impacts to the surf clam resources and cultural artifacts.

Given the rebound of the surf clam population along much of southern New Jersey's offshore region, it has become virtually unavoidable to identify suitable sand resources which do not contain commercially viable surf clam beds. Data from NJDEP's Bureau of Shellfisheries confirm that there may be no locations offshore of Absecon Island (other than within Absecon Inlet itself) where surf clam populations are of a sufficiently low concentration to allow sand mining for beachfill purposes. Given the apparent abundance of surf clams offshore of southern New Jersey, it is questionable whether the proposed dredging will actually have a measurable impact to the overall vitality of this resource.

As stated in our report (pg. 201), the proposed beachfill project requires a conservative estimate of approximately 32 million cubic yards (cy) over its anticipated 50 year project life. Initial construction of the project would require approximately 6.2 million cubic yards (cy) while the periodic nourishment is estimated at 1.7 million cy every three years. These quantities are based on existing grain size characteristics within the 3 sites. Of the three sites, Site A has the largest composite grain distribution. Given the importance of grain size to the beachfill quantities (finer grain size requires more quantity to achieve similar project performance), utilizing different sites which have a finer composite grain characteristic could greatly increase both the volume of sand required as well as the overall cost. Increasing the acreage of the borrow area(s) would have the negative side effect of expanding the potential disturbance zone of the surf clams during dredging.

The originally proposed dredging strategy entailed full utilization of Site A for initial construction and early nourishment cycles. Sites B and C were proposed only if and when needed during future nourishment efforts based on the infilling which would naturally occur at Site A. This was developed to minimize the unavoidable impacts to the existing surf clams which have a larger concentration in sites B & C.

Land Use and Regulation inquired about alternative sites (as many as 15) which were understood to have been part of our early borrow site analysis. The 15 sites actually represent vibracore test sample boring locations and not individual borrow areas. The COE was also requested to further investigate the possible use of the Great Egg Harbor Inlet ebb shoal. This ebb shoal complex contains a large quantity of beach quality sand. The COE was reluctant to focus on this site (other than site C on the northern portion of the shoal) because of the potential negative impact additional sand extraction might have on the existing Federal project at Ocean City which utilizes this ebb shoal as its primary borrow area.

Nonetheless, after the Absecon Island project is constructed, the COE is willing to perform additional monitoring and studies of the Great Egg Harbor shoal complex to see if additional sand extraction is prudent. It is likely that by constructing the Absecon Island project, a significant increase in the volume of sand will occur within the nearshore littoral system along, and downdrift (south) of Absecon Island. This could increase the volume of sand moving into the Great Egg Harbor ebb shoals, allowing for increased mining at this location (a form of sand recycling). Additional post-construction monitoring would be required, however, to confirm this concept.

During the meeting held on July 19, it was noted by the Division of Fish, Game and Wildlife that utilization of existing sand within Absecon Inlet proper was acceptable. Both the COE and NJDEP concurred that there currently exists a sizable quantity of material (approximately 3 million cubic yards) located in the sub-aerial beach and dune system along the Brigantine side within Absecon Inlet. However, the characteristics of the underlying material are not known and may include peat layers or other fine grained material and not beach quality sand.

Furthermore, this location is considered a desirable natural beach and dune habitat which also has significant recreational usage. Dune habitat such as this has received great attention from resource agencies and the public as important features which should be preserved within the highly developed barrier islands of New Jersey. Both the COE and the NJDEP's Engineering and Construction Element view this as an unacceptable alternative which is very strongly opposed by the City of Brigantine and undoubtedly by other resource agencies or departments within NJDEP. Loss of this dune area may also be in violation of NJAC Dune rules 7:7E-3.16. Even if this location could be dredged, there is not a sufficient quantity of sand within the inlet zone to provide the sand quantities required for future nourishment operations.

Following the July 19 meeting, subsequent discussions within NJDEP resulted in the request to specifically review Site A. The intent was to maximize the usage of sand within the inlet throat, and lessen the intrusion north of the Brigantine jetty into the surf clam conservation zone. A re-designed borrow site A is enclosed as attachment 3.

We have estimated that approximately 300,000 cy of material per year may infill Site A between nourishment intervals (900,000 total for the 3 yr cycle). This is a difficult quantity to predict and is viewed as a conservative estimate, particularly after the project is constructed. Our analyses indicate that there is considerably more sand currently being transported in the littoral system along Absecon Inlet (on the order 550,000 cy). Following the construction of the project, additional sand will become available to the ongoing littoral processes. Thus, there should be a significant increase in the gross transport of sand, most notably from the northern portion of Atlantic City, both north into the inlet as well as further south along Absecon Island. In addition, once the Absecon Inlet borrow site has been dredged, it will create a localized sediment sink which will be more effective at trapping sand entrained in the littoral system. Therefore, the actual infilling of Site A may be greater than predicted. This would cause Site A to have additional longevity over what is currently estimated.

Based on existing bathymetry, the re-designed Site A contains approximately 10.3 million cy of beach quality sand. This quantity is based on dredging to depths of -40 feet MLW within the inlet and-35 feet MLW in the ebb tidal delta region. These are the deepest depths currently recommended based on available information. An additional 1 million cy of material is estimated to naturally deposit into Site A area prior to construction, for a future total of approximately 11.3 million cy. Assuming an initial beachfill requirement of 6.2 million cy, that would leave a balance of just over 5 million cy for future nourishment efforts (in addition to the infilling volume of 900,000 cy per 3 yr cycle). Therefore, the Absecon Inlet site can reasonably be expected to be the sole source of beachfill

material for the initial construction and first six to seven nourishment efforts (approximately years 2019-2022). Post project monitoring will confirm the actual beach losses and borrow site infilling. Changes in nourishment requirements, grain size distributions, infilling rates, etc., could either increase or decrease the projected time horizon for sole utilization of Site A for sand mining.

During the period following the feasibility study, more detailed project design efforts will be underway. The COE will continue to investigate the offshore region and coordinate with departments within NJDEP to locate additional sites which are mutually agreeable for sand extraction. These efforts can continue even after initial construction since conditions change and updated data may be required. In addition, prior to each dredging effort the COE will coordinate with the appropriate resource agencies to establish a suitable period for pre-harvesting of existing clam populations.

The COE and NJDEP's Engineering and Construction Element also propose to fund a longterm, in-depth study of surf clam recolonization in and around borrow sites in southern New Jersey. Borrow Site A would be a likely location to conduct this study. This study should provide much needed data on the impact of sand mining on indigenous benthic communities within southern New Jersey waters. Study efforts and conduct would be fully coordinated with the NJDEP's Bureau of Shellfisheries and other interested parties.

Berm Width

The recommended berm width of 200 ft. along Atlantic City is the result of a detailed systematic analysis of the physical and economic performance of varying beachfill designs within the project area. The COE utilizes rigorous numerical models and analyses to determine the optimal plan based on site specific data and information, and the subsequent comparison of benefits and costs. It is not appropriate to simply assume that a smaller beach width is sufficient for one location by referencing similar widths which have been individually developed and designed for other locations. Our efforts confirmed that a 200 ft. berm width for Atlantic City was the optimal plan (largest net benefits over costs; refer to Table 40) while the remainder of the island optimized at 100 ft. (Table 42). This plan is consistent with previous plans developed by both the COE and NJDEP and is fully supported by the project sponsor and community. Atlantic City is experiencing severe erosion along portions of its shoreline leaving the community potentially extremely vulnerable during future storm events. Given the significant economic investment along Atlantic City's shorefront, the larger berm width was confirmed to be the most cost effective means in providing additional shore protection.

BULKHEAD AND REVETMENT ALONG ABSECON INLET

The construction of a bulkhead and revetment located between Atlantic and Oriental Avenues has raised an issue relative to the elimination of an existing beach (NJAC 7:7E-3.22), and the filling of a portion of water area (NJAC 7:7E-4.2). Further information regarding this proposal as well as alternative solutions or locations were requested to be considered to avoid these impacts. Better details of the location of the bulkhead were shown at the July 19 meeting and are included as attachments 4a & 4b.

The bulkhead is designed to provide storm protection to the existing boardwalk and upland development along this portion of Atlantic City's inlet frontage. Both locations where the bulkhead was recommended currently have less existing protection than adjacent areas. The project would thus provide for a consistent level of protection along the entire Absecon Inlet frontage which currently does not exist. Significantly increased development and urban renewal of the inlet region of Atlantic City is being planned for the near future and is already underway in many areas.

Relocation of the bulkhead landward behind the boardwalk and above the spring high tide line was confirmed as not being cost effective since it would not reduce recurrent damages to the boardwalk. This was one of the principle objectives of recommending the bulkhead in this location since the city wants to maintain the ambiance of the boardwalk as this portion of Atlantic City undergoes a revitalization. It was also confirmed that relocating the boardwalk to a more landward position was not economically feasible (Table 31).

Nine other structural and non-structural alternatives were reviewed during our formulation process (summarized in Tables 30, 31 and 35 of main report). The bulkhead with toe revetment were concluded to be the most effective and economical feature to reduce the damage potential for this portion of the inlet shoreline. The bulkhead is also consistent with virtually all of the other existing structural features along Absecon Inlet.

Construction of the bulkhead requires backfilling to ensure the structural integrity of the bulkhead (see bulkhead design detail, attachment 5). This would result in the filling of approximately 0.3 acres of intertidal beach water area. This "beach", however, is principally comprised of remnant building rubble and is widely regarded by the sponsor and local community as being a visual blight with marginal environmental value and no recreational or other public use (refer to figure 23 on pg 98 of report). In addition, the shoreline in this area has been

receding, with the proposed bulkhead location actually landward of the State's 1986 MHW line. The existing shoreline is expected to continue to erode, eventually requiring stabilization at a more landward position in the future. Therefore, the construction of the bulkhead at the recommended location would stabilize the shoreline along an area where it would ultimately be lost anyway. The backfill required for construction of the bulkhead would also improve the aesthetics of the area and create additional public use opportunities.

Following the feasibility study, the COE undertakes additional and more detailed design efforts leading to the development of plans and specifications prior to construction. During this period, the Corps is willing to explore opportunities to place an appropriate quantity of sand in front of the new bulkhead and revetment. This would essentially replace the existing eroded rubble beachface with a more natural sand beach in a position where it previously existed. This could be incorporated into both the initial beachfill construction contract as well as future nourishment efforts in order to maintain a sandy beachface along Absecon Inlet. Coordination with the appropriate resource agencies would have to occur to ensure the acceptability of this proposal.

BEACH ACCESS

Further detail was requested regarding beach access over the dunes to determine consistency with applicable dune regulations (7:7E-3.16 and 3A). A follow up phone call by Ted Keon, COE's Chf. Coastal Planning Section with Mark Mauriello of NJDEP's Bureau of Coastal Regulation assisted in the further clarification and reasonableness of the COE's proposal.

The beach access strategy currently recommended by the COE is to provide natural beach walkover paths, up and over the dunes at a skewed angle and delineated by sand fencing. The sponsor is responsible for maintaining the access ways by replacing fencing as needed, and providing additional sand fill if the access way degrades upon the design dimensions of the dune template. These walkovers would be strategically placed at most street ends or other high traffic areas. The final location and dimensions of these walkovers and access ways will be coordinated with the sponsor and local communities during the preparation of plans and specifications. These walkover paths are in addition to any existing structural walkover features currently in place. The section describing dune access in the report and EIS will be expanded and clarified.

No additional elevated timber pile and step, or other semi-permanent walkover structures are proposed. Natural walkovers were preferred to construction of timber structures for a variety of reasons. Timber structures can be expensive to build, and in areas subject to repeated storm activity can have high maintenance costs for repair or reconstruction. Natural walkovers have become the common usage in this area and was the preferred method for access by both the sponsor and local communities.

At grade pathways cut through the dune currently exist at the southern end of Atlantic City. The COE's proposed dune and access plan will greatly improve upon this by ensuring a consistent level of protection by a fully developed dune system without gaps at access ways.

Vehicular access will be afforded at existing vehicular access points. These areas will be strengthen by rollup articulated pressure treated timber matting. These areas will also provide handicapped access as well. The final location and number of vehicular and or handicapped access points will be further coordinated with the communities during the development of plans and specifications.

The local communities may have special, site specific requirements for beach access appurtenances which may require the construction of additional, or modification of proposed access paths. This is conditionally acceptable with the COE as long as the access plans are fully coordinated with the COE to ensure no loss of project integrity, and with NJDEP for adherence to State coastal zone regulations.

Richard Kropp, Director
NJDEP, Land Use Regulation Program
CN 401
Trenton, New Jersey 08625

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL
PROTECTION AND ENERGY
Office of Program Coordination
CN 418
Trenton, NJ 08625-0418
Phone 609-292-2662
Fax 609-777-0942

July 25, 1996

Mr. Robert L. Callegari
Chief, Planning Division
Philadelphia District, Army Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

RE: Absecon Island

Dear Mr. Callegari:

The Office of Program Coordination of the New Jersey Department of Environmental Protection has completed its coordinated Departmental review of the Draft Environmental Impact Statement (EIS) for the Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island Interim Feasibility Study. We offer the following comments and concerns regarding potential environmental impacts on natural resources.

It is the view of our Department's Division of Fish, Game and Wildlife that potential project related adverse impacts to fish and wildlife resources could be avoided or minimized by acknowledging the following natural resource concerns and incorporating the suggested recommendations.

The Division's Bureau of Shellfisheries annual Surf Clam Inventory has shown commercially viable surf clam (Spisula solidissima) stocks exist in the water offshore of Absecon Island. This area has historically supported commercial surf clam harvest activities. In addition, data collected by Versar, Inc. on October 25, 1995 at the proposed borrow sites corroborates with data collected by the Bureau.

Since the proposed borrow sites are located within productive surf clam habitat, sandmining activities could result in the destruction, condemnation, or contamination of surf clam areas. As this issue is burdensome to the project as proposed, continued consultation with our Bureau of Shellfisheries is crucial and necessary (such as the recent July 17, 1996 meeting conducted in Trenton).

The Bureau of Marine Fisheries has offered the following recommendations to avoid and reduce impacts to the marine resources off Absecon Island.

(1) Borrow pit design should preserve ocean bottom topography by restricting dredging activities to board areas with relatively shallow and uniform depths in order to promote rapid recolonization of biota.

(2) Borrow areas should not impact upon shipwrecks or natural bathymetric features which have a demonstrated history of supporting a significant level of recreational or commercial fishing activity.

(3) The post-construction monitoring for the project, which consists of sediment sampling of the beach and borrow areas, should also incorporate post-construction benthic macroinvertebrate assessment in order to evaluate recovery rates and to develop mitigation measures if necessary. Results of such an assessment are needed to evaluate future renourishment plans and should be provided to resource management agencies for review and comment prior to any additional renourishment activities.

Thank you for giving us the opportunity to comment on the Draft EIS for this important project. The New Jersey Department of Environmental Protection is committed to resolving the issues raised in this letter. Continued dialogue between our two agencies hopefully will result in implementation of a modified project.

Sincerely,

Lawrence Schmidt
Director
Office of Program Coordination

c: Robert McDowell, NJDEP
Richard Kropp, NJDEP
Jim Hall, NJDEP
Bernard Moore, NJDEP

1. For the purposes of this project, the Absecon Inlet borrow area was designed to provide the required amount of sand for beachfill, while impacting the smallest amount of surface area possible. This was done primarily to minimize impacts to surf clams and other benthic organisms. During the dredging of sand from the inlet it will be necessary to excavate sand to a depth approximately 15 - 20 feet below its current elevation. It is believed however that this sand will be readily replaced through the natural forces acting on the inlet. This replacement of sand will enable this borrow area to be used for future nourishment cycles as well.

2. No shipwrecks or other bathymetric features will be impacted within the borrow area. A magnetometer survey was completed for the borrow area and the borrow area size and shape reflect the results of this survey. All shipwrecks will be avoided, and a 200 foot buffer zone will be in place around all known shipwrecks to insure that these areas will not be negatively impacted.

3. Concur. The post-construction monitoring will include a post-construction benthic macroinvertebrate assessment. All information will be fully coordinated with the appropriate resource agencies.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
408 Atlantic Avenue - Room 142
Boston, Massachusetts 02210-3334

June 14, 1996

ER-96/0324

Lt. Colonel Robert P. Magnifico
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Magnifico:

The Department of the Interior (Department) has initiated the review of the Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island Interim Feasibility Study - Draft Feasibility Report and Draft Environmental Impact Statement (DEIS). The subject DEIS addresses shore protection for the communities of Atlantic City, Ventnor, Margate, and Longport, New Jersey. The Department has the following comments on the proposed project.

ENVIRONMENTAL REVIEW PROTOCOL

1. The U.S. Fish and Wildlife Service (Service) is currently preparing a Fish and Wildlife Coordination Act (48 Stat. 401, 16 U.S.C. Sec. 661 *et seq.*)(FWCA) Section 2(b) report documenting fish and wildlife resources in the project area, identifying potential adverse impacts to those resources, and providing recommendations to minimize adverse impacts. The Service's FWCA Section 2(b) report will be completed by July 2, 1996. The National Environmental Policy Act (NEPA) (83 Stat. 852, 42 U.S.C. 4321 *et seq.*) Section 1502.25 requires that the U.S. Army Corps of Engineers (Corps) "prepare draft environmental impact statements concurrently with, and integrated with, environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act" and the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). The Corps is currently requesting comments on the DEIS (i.e., June 17, 1996) prior to the Service's completion and submission of the FWCA Section 2(b) report. Since the Corps has not integrated the Service's FWCA Section 2(b) report with the DEIS, it is the Department's finding that the Corps has not complied with Section 1502.25 of NEPA. The appropriate scheduling requires that the Corps request and receive the Service's draft Section 2(b) report for inclusion in the Draft Feasibility Report and DEIS prior to requesting comments on the DEIS. Therefore,

1. The comment period was extended as requested.

the Department recommends that the Corps extend the comment period of the subject DEIS until 15 days after the draft FWCA Section 2(b) report is completed (i.e., until July 17, 1996).

GENERAL COMMENTS

The Department has identified several concerns regarding the proposed project including potential adverse impacts on the federally listed (threatened) piping plover (*Charadrius melodus*) and finfish. The Department also has questions regarding the benthic monitoring program, the protocol for dredging within the identified borrow sites, and the potential for development within the proposed restored area. Upon completion of the Service's FWCA Section 2(b) report, the Department will provide detailed comments on the above-mentioned concerns.

CONCLUSION

As confirmed on June 14 by your contact for this project, Beth Brandreth, the Corps has provided the Department with an extension of the DEIS comment period until July 17, 1996. This extension will provide the opportunity for Fish and Wildlife Service to complete and for the Corps to review the draft FWCA report, respectively, as well as for the Department to provide its overall comments on the DEIS. The Department will continue to cooperate fully to resolve the aforementioned concerns.

If you have any questions regarding these comments or require further assistance on issues regarding fish and wildlife resources in New Jersey, including federally listed threatened or endangered species, please contact the Service at the following address:

Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
Ecological Services
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
(609)646-9310

Thank you for the opportunity to provide these comments.

Sincerely,

Andrew L. Raddant
Regional Environmental Officer

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Affairs
408 Atlantic Avenue – Room 142
Boston, Massachusetts 02210-3334

July 16, 1996

ER-96/0324

Lt. Colonel Robert P. Magnifico
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Magnifico:

The Department of the Interior (Department) has reviewed the Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island Interim Feasibility Study - Draft Feasibility Report and Draft Environmental Impact Statement (DEIS). The subject DEIS addresses shore protection for the communities of Atlantic City, Ventnor, Margate, and Longport, New Jersey. The Department has the following comments on the proposed project.

FISH AND WILDLIFE COORDINATION ACT COMMENTS

Benthic Organisms

The Department assumes that borrow area "D" (Brigantine Inlet) was eliminated from consideration due to its distance to the proposed project area. Borrow area "D" would be the preferred borrow source due to its apparent low density of surf clams (*Spisula solidissima*). Since removal of material from borrow area "D" is apparently not feasible, the Department concurs with the Corps proposed use of borrow area "A" (Absecon Inlet) as the preferred borrow source. Compared with other potential borrow areas, borrow area "A" had the lowest benthic organism abundance, lowest species diversity, and lowest surf clam abundance. However, borrow area "A" is still considered to be a productive area for surf clams (Norman, pers. comm., 1996). To ensure that impacts to surf clams are minimized to the extent possible, the Department recommends that the Corps consult with the New Jersey Bureau of Shellfisheries.

Dredging a borrow area results in the removal of sediment and organisms from the borrow area and potentially creates adverse impacts on water quality. Upon initial beach nourishment, as proposed, approximately 345 acres of benthic habitat would be adversely impacted, resulting in substantial mortality of benthic organisms. Long-term impacts on borrow areas include potential changes in circulation patterns affecting the pattern of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing, which can cause anoxic conditions affecting benthic organism recovery. Additionally, removal of sand ridges at the proposed borrow sites may eliminate productive surf clam habitat, reducing the value and productivity of the borrow area for these organisms (Norman, pers. comm., 1996). In order to avoid establishing anoxic conditions in the borrow area, the Department recommends avoiding any creation of excessively deep, poorly flushed borrow pits.

Most benthic organisms within the ocean's dynamic ecosystem have adapted to periodic changes in habitat that occur as a result of northeasters, hurricanes, and other storms. As a result, and provided the habitat is still suitable, benthic organisms typically recolonize an area quickly. Saloman *et al.* (1982) concluded that benthic organisms recover from dredging events in approximately 1 year, with minor sedimentological changes, and with a small decline in diversity and abundance within the benthic community. The Corps has also determined that recolonization of borrow areas would occur within 1 year within the project area (U.S. Army Corps of Engineers, 1996). However, disturbances within the borrow areas every 3 years for the life of the project (i.e., 50 years) would likely limit recolonization, thereby maintaining low infaunal abundance and low species diversity.

In order to minimize repeated impacts on benthic organisms within the borrow area, the Department recommends that the Corps conduct each renourishment dredging phase in a limited portion of the borrow area and alternate locations for each subsequent renourishment cycle. This concept of rotational dredging minimizes frequent, repeated disturbance of a particular area, thereby allowing recolonization of benthic organisms to occur over a longer period of time.

Typically, hydraulic-pipeline dredging is preferred by the Department over hopper dredging because it minimizes turbidity. Therefore, the Department recommends the use of hydraulic-pipeline dredging over hopper dredging. The Department also recommends dredging during the period of lowest biological activity (November to January) to minimize adverse impacts on benthic organisms.

If previously identified borrow areas other than borrow area "A" are required for subsequent renourishment cycles, the Corps proposes to initiate update surveys to determine current benthic population characteristics. In addition, the Corps proposes to implement a benthic monitoring program, concurrent with periodic maintenance activities, to document project-related impacts and aid in avoiding impacts to sensitive areas during the periodic maintenance activities. The Department recommends that the Corps provide the federal resource agencies (e.g., U.S. Fish and Wildlife Service and National Marine Fisheries Service) with copies of the borrow area update surveys, the benthic monitoring program, and results of the benthic monitoring program.